Engineering News

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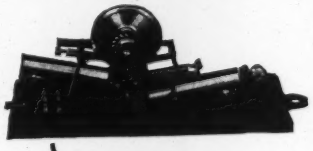

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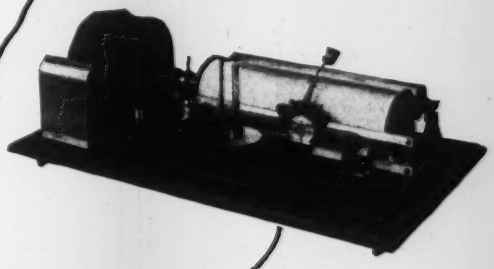

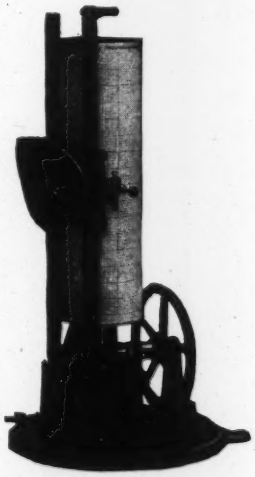

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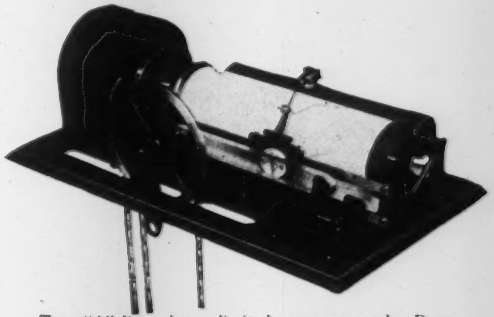

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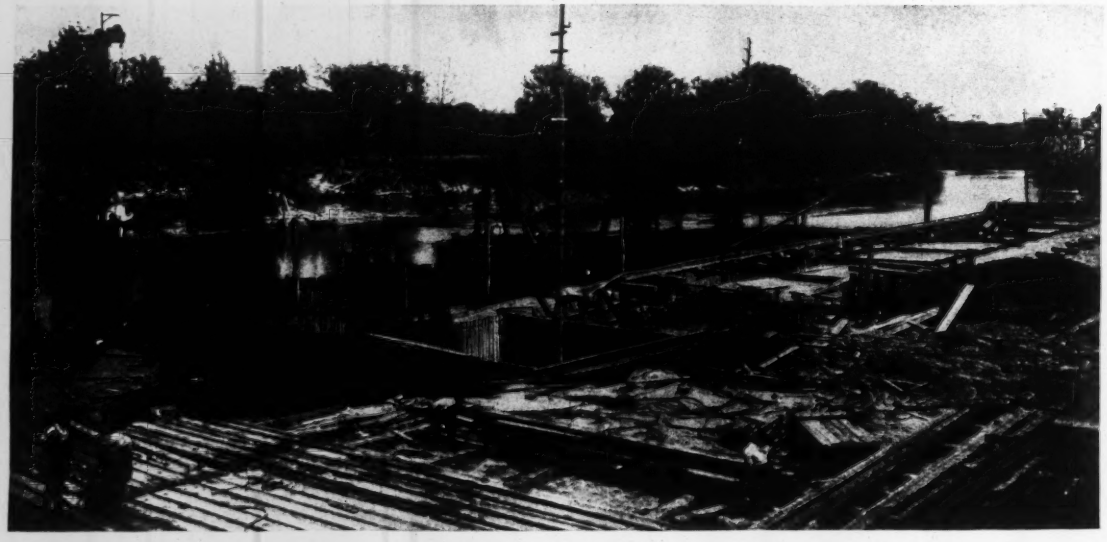
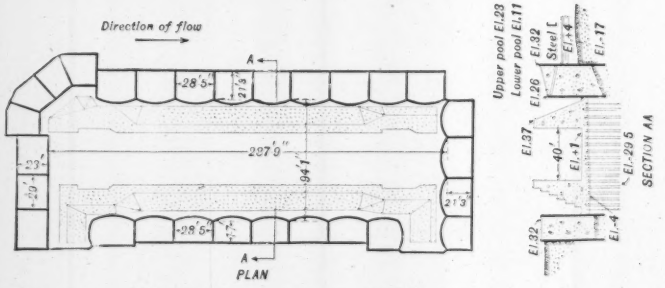


Driving Lackawanna Steel Sheet Piling in the Cofferdam for Lock No. 2, Cape Fear River, Brown's Landing, N. C.

The steel in the land wall (See description of cofferdam in last week's advertisement) was driven by two pile drivers traveling on the bank, and carrying respectively 3,000-lb. and 1,800-lb. steam hammers. The penetration varied from 39 to 48 feet in clay, sand and marl, and in several instances where difficulty was encountered in driving to grade the piling tops were cut off by the oxy-acetylene process. The smaller hammer averaged driving 9 and the larger 25.6 piles per 16-hour day.



On completion of the land driving, dredging at the upper and lower ends was done to permit more flexible floating driving rigs mounted on scows to continue the coffer walls out into the river. The penetration here being but 18 to 21 feet, the average driving rate was increased. Jets were freely used in both land and river driving.

The curved panels in the river wall were driven to a template floating on the convex side of the arcs and held in place by adjustable bracing to wooden pilot piles located in the cofferdam as shown in the picture. The bracing was so arranged that the template could rise and fall with varying water levels.

A gap was left at the lower end of the cofferdam for the passage of the excavating dredge and the drivers which drove the foundation piles, and until after the bottom had been sealed by a 5-foot layer of concrete deposited through a tremie.

The driving costs were as follows:

	Per Pile	Per Ton	Per Lin. Ft.
Driving land piling	$5.18	$5.77	—
Driving river piling	2.28	2.53	—
Driving piling, average	3.36	3.75	—
Splicing piles	.47	—	—
Handling piles	.30	—	—
Placing wales	—	—	$0.79
Driving wood anchor piles	4.57	—	—

More particulars concerning this cofferdam will be given in next week's advertisement. In the meantime send for *and read* our book—"Lackawanna Steel Sheet Piling."

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Engineering News

VOLUME 76 DECEMBER 14, 1916 NUMBER 24

Ten-Span Concrete-Arch Bridge Near Columbus, Ohio

By E. P. Knollman*

SYNOPSIS—Article gives in considerable detail the items of interest in the design and construction of a long reinforced-concrete arch bridge of no special complication. Interest of article is mainly in fact that it represents the latest standards of practice in concrete-bridge construction.

The Agler bridge, just completed over Alum Creek in Franklin County, Ohio, is located about 5½ mi. northeast from Broad and High St., Columbus, Ohio. The structure is of reinforced concrete with a total length of 1,166 ft. and an overall width of 27 ft. 2 in. It consists of ten arch spans of varying lengths, with three small trestle spans at the west end and three similar spans and curved retaining-wall approach at the east end. The length of the various spans, beginning at the west end, is as follows: Three 10-ft. 2-in. trestle spans, ten ribbed arches having the following clear spans—67 ft. 8 in., 90 ft. 8 in., 90 ft. 8 in., 113 ft. 8 in., 136 ft. 8 in., 136 ft. 8 in., 113 ft. 8 in., 102 ft. 2 in., 90 ft. 8 in. and 44 ft. 8 in.; three 10-ft. 2-in. trestle spans and a curved retaining-wall approach. All of the arch piers and eight of the trestle piers are supported on wood pile foundations. The bridge has a 20-ft. clear roadway and one 4-ft. clear sidewalk, the latter placed on the north side of the bridge so that the amount of snow and ice will be a minimum.

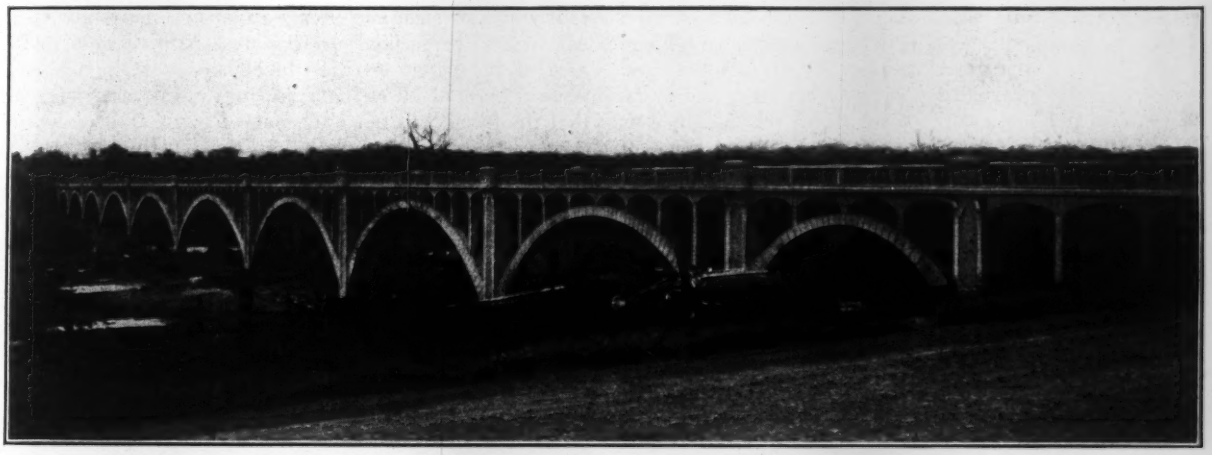


FIG. 1. VIEW OF ONE END OF THE COMPLETED AGLER BRIDGE IN FRANKLIN COUNTY, OHIO

The bridge is so designed that all spandrel spans and the six trestle spans are of the same length. Floor-beams spaced 11 ft. 6 in. apart frame into spandrel columns, the distance between floor-beams being spanned by a 12-in. slab. Each arch consists of two ribs spaced 20 ft. on centers. In order to provide for variations in temperature and rib shortening, all arch ribs have a crown section in which the depth of the rib is less than the width. The crown sections of the arches vary from 25x34 in. for the 67-ft. 8-in. span to 39x42 in. for the 136-ft. 8-in. span.

In computing temperature stresses it was assumed that any rise in temperature would be balanced by rib shortening under dead-load. The ribs were designed according to the method given by Turneaure and Maurer, provision being made for a drop in temperature of 25° F., which, combined with rib shortening, made a total drop of 50° F. The bridge is designed for the following live-loads: For the floor and its supports a uniform load of 200 lb. per sq.ft. on the roadway and 100 lb. per sq.ft. on the sidewalks, each with 25% impact, or a concentrated load on the roadway of a 24-ton truck and a uniform load of 100 lb. per sq.ft. on the sidewalk, each with 25% impact; for the arch rings and foundations a uniform load of 100 lb. per sq.ft. on both roadway and sidewalk, each with 25% impact. The allowable stresses used in this design were as follows: Concrete in compression, 650 lb. per sq.in., except in arch rings, where 700 lb. per sq.in. (including rib shortening and temperature) was allowed; concrete in shear, 50 lb. per sq.in.; steel in tension, 16,000 lb. per sq.in.; steel in compression, not more than 15

*Assistant County Surveyor, Franklin County, Ohio, Columbus, Ohio.

times the unit compression in the surrounding concrete. The maximum load per pile is 20 tons. The entire bridge, with the exception of the concrete pavement and concrete railing, is built of 1:2:4 concrete, using Medusa portland cement, Canadian sand and crushed limestone.

The concrete pavement is a 1:2:3 mixture of the same materials as the bridge proper. It is 5 in. thick and is laid on the 12-in. floor slab after the slab has been waterproofed with a layer of fabric and two coats of asphalt. The pavement is reinforced with a mesh weighing 28 lb. per 100 sq.ft., and is placed in the center of the 5-in. slab. Over each arch pier there is an expansion joint in the pavement. Kahn armor plate was used at all expansion joints.

The concrete railing is a 1:1½:2½ mixture of portland cement, silica sand and granite chips. The sand was graded from ¼ in. down and the granite chips from ¼ in. to ⅜ in. All railing posts were tooled with a patent hammer and all web sections scrubbed so as to expose the aggregate. No tooling was done before the concrete was at least one month old and in tooling the large railing posts considerable difficulty was experienced in holding the edges true. Accordingly, for the small railing posts a margin of 1 in. around all corners was rubbed and the remainder of the posts tooled.

Expansion and Drainage

Expansion in the concrete railing was carefully considered, and in the design adopted there are no horizontal sliding surfaces and no inserts, but both ends of each 10-ft. 4-in. panel have vertical expansion surfaces. There is absolutely no connection between the railing posts and web sections. The expansion surfaces are separated by an air space of not more than ½ in. which was obtained as follows: The railing posts were poured; then a piece of heavy gage sheet steel was placed at the ends of the wet forms and ordinary shingles were used to wedge between the railing posts and the sheet steel. This wedging was carefully done so that upon removal of forms the ends of the web are parallel to the railing posts. Previous experience has shown that expansion or contraction is especially difficult to provide for in concrete railings and that the expansion joints in such a railing must be close together if unsightly cracks are to be avoided. In addition, a considerable amount of reinforcement should be placed in the railing.

In designing the bridge especial attention was given to drainage and expansion, and an effort was made to correct such defects as have developed in similar structures previously built in Franklin County. To provide for drainage, scuppers are so placed that the water will not flow over an expansion joint before reaching the inlets. The storm water is carried through 6-in. cast-iron pipe to a point about 10 ft. above the ground and there discharged. The drainage system is so arranged as to be invisible in a side view of the bridge.

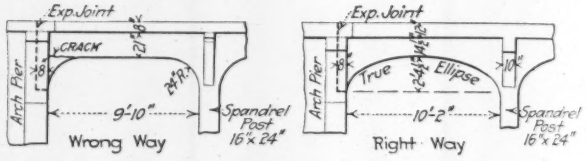


FIG. 3. WRONG AND RIGHT WAY TO DESIGN FASCIA GIRDERS

At expansion joints the horizontal sliding surfaces have been reduced to a minimum; and where they do occur, rolled steel or steel and bronze expansion plates are used. All vertical expansion surfaces are separated by a thickness of tar paper or Elastite expansion strip, and the vertical sides of all stringer bearings are beveled in order that the joints will not bind, but will tend to open whenever contraction takes place. In constructing the earlier sidewalks the tar paper at the vertical expansion joints was cut off about ¼ in. below the finished surface of the sidewalk. At such points spalling of the sidewalk has occurred from the surface of the sidewalk to the point where the paper was cut off. As a result, felt ½ in. thick,

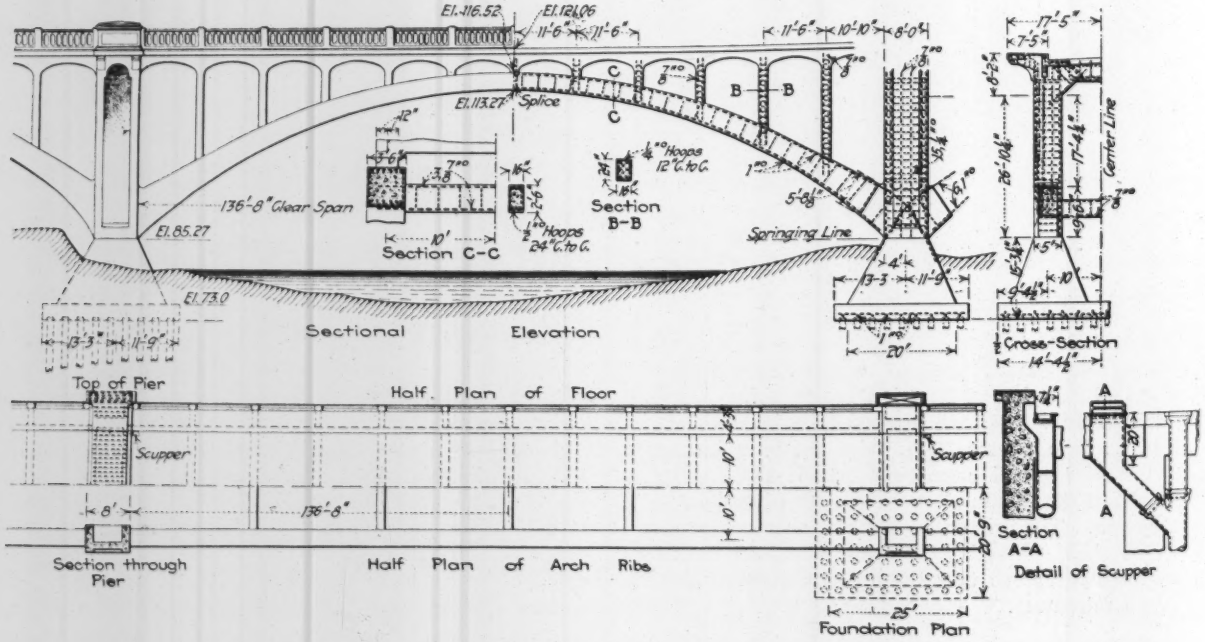


FIG. 2. DETAILS OF ONE OF THE LARGE ARCHES OF THE AGLER BRIDGE

extending through the surface of the sidewalk, is now used for all vertical sidewalk expansion joints.

The writer was resident engineer on the construction of a large ribbed arch bridge during the summer of 1914, in which the spandrel face beams were as shown at the left in Fig. 3. In several cases at expansion joints these fillets cracked, as shown. To remedy this defect an ellipse was used for the spandrel beams of the Agler bridge, as may be seen at the right in Fig. 3.

The outside faces of all arch ribs are divided into sections by means of rustications, as illustrated in Fig. 1. This improves the appearance of the structure to a considerable extent. In the opinion of the writer any means employed to break up large, plain surfaces improves the appearance of concrete work. When designing a concrete structure all construction joints should be located and an effort made to hide them by means of rustication or otherwise.

The exposed surfaces of the bridge are finished by rubbing in a thin mortar with carborundum brick when the concrete is from two to six days old, and later on when the work is finished the concrete is given a second rubbing with carborundum and water.

The bridge is wired for lighting, a 2-in. fiber conduit being embedded in the coping. This fiber conduit is weak at the joints, and a standard metal conduit is to be preferred. Fuse boxes of brass, with aluminum faces and doors, are used. They have hinged doors, are provided with locks and are placed on the outside of the bridge.

Construction Methods

Two stiff-legged derricks served for driving the Wemlinger sheet-steel piling for the coffer-dams, for excavating with orange-peel buckets, for driving the foundation piling, for depositing concrete, pulling sheetpiling and for backfilling. Fig. 4 shows practically all the equipment employed on the job. The light-weight Wemlinger sheetpiling was very satisfactory, as was the orange-peel bucket. The foundation piles were driven with No. 2 Union steam hammers. For the footing and pier-base concrete two Ransome "Bantam" mixers were used. The main concrete-mixing plant consisted of a ¼-yd. Ransome mixer and an elevating tower. The concrete was deposited by means of chutes and buggies. The concrete mixer and elevating tower were moved twice during the construction of the bridge. Steam for the large concrete mixer, hoisting engines, pumps, derricks, pile hammers, etc., was piped from two central plants. Materials were hauled 1½ mi. from the railroad siding to the bridge site. Wagons were used for hauling, which cost 55c. per cu.yd. for sand and stone.

The arch centers are very light and were built as shown on the centering plan in Fig. 5. All centering was spiked,

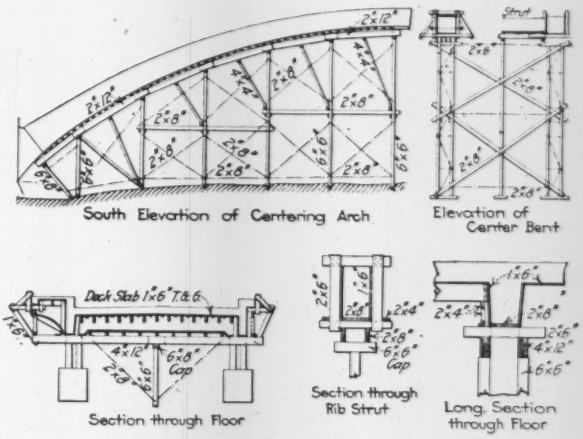

South Elevation of Centering Arch
Elevation of Center Bent
Section through Floor
Section through Rib Strut
Long. Section through Floor

FIG. 5. DETAILS OF CENTERING FOR AN ARCH IN THE AGLER BRIDGE

no bolts being used except where centering posts were spliced. For checking the intrados of the arches a board about 15 ft. long with one edge cut to proper radius was slid around the arch barrel. The first six arches were poured by starting at the haunches and completing one entire rib at one pouring, with the use of bulkheads. The other four arches were poured in sections, haunches first, then crown and lastly intermediate sections. The rib forms and all deck forms were so designed that they could

FIG. 4. VIEW OF AGLER BRIDGE UNDER CONSTRUCTION

be used several times. This was done with fair results. After being used three times, the 7/8-in. forms were in such shape that considerable rebuilding and repairing were necessary. The writer believes that it would be advisable to limit the number of times forms may be used. The contractor states that he has applied for patents on the general centering scheme.

The bridge contract includes about 5,000 cu.yd. of excavation, 20,000 lin.ft. of piling, 5,100 cu.yd. of concrete and 202 tons of reinforcing steel. The total cost of the bridge is about $102,500, or $3.25 per sq.ft. overall, including cost of handrail and pavement. Construction was commenced in the summer of 1915 and the last concrete in the pavement was poured the latter part of October, 1916. To date no cracks have been observed in the structure anywhere.

The contractor for the bridge is the Stewart Engineering Corporation, of New York City. John Peake is County Surveyor. The bridge was designed by the writer under the supervision of Walter Braun, County Bridge Engineer. The computations were checked by W. J. Watson & Co., of Cleveland, Ohio. The writer was the resident engineer for the county.

Plan for Raising the Height of Morena Dam

As a measure of safety to prevent the Morena dam from being overtopped in case of another flood such as that which southern California experienced last January, the City of San Diego is making preparations to add 5 ft. to the height of the dam in order to increase the spillway capacity. City Engineer George Cromwell has recommended this improvement in a report that the city council has accepted, and it is expected that work will be commenced within a very few weeks.

The Morena dam is a rock-fill structure that was completed in 1912. Its reservoir was filled for the first time by the flood of last January. Prior to that time it had been considered that the spillways of both the Morena and the Lower Otay dam, which failed during this storm, were more than sufficient to care for any runoff that might come into either of the reservoirs. This belief, however, was erroneous, for the runoff into each of these reservoirs was much greater than the capacity of the spillway of either dam. The water level in the Morena reservoir was so low that the capacity of the reservoir absorbed the greater portion of the runoff, and the spillway took care of the remainder, although when the storm was at its height the water came within 18 or 20 in. of the top. It is feared, however, that should the coming winter season bring heavy rains the runoff will again exceed the capacity of the spillway, and with the increased height of the water level the dam will be topped.

Mr. Cromwell in his report makes the following conclusions after a careful study of the rainfall, runoff and flood conditions at the Morena reservoir for the past season:

The water level in the reservoir stood at 138.5 ft. at 7 a.m. on Jan. 27, and during the 24-hr. period from 7 a.m. Jan. 27, to 7 a.m., Jan. 28, 1916, there was a runoff of 5,707,000,000 gal., or enough additional water to fill the reservoir to within 18 in. of the top of the dam with the spillway running wide open all the time. If the water level in the reservoir had stood at 141.5, or only 3 ft. higher than it actually was at 7 a.m. on Jan. 27, it would have been impossible to prevent the water from filling the reservoir and flowing over the top of the dam just as it did in the case of the Lower Otay.

It is impossible to say just what would be the consequence if any considerable quantity of water was allowed to flow over the top of Morena dam, but there is a very grave question if the dam would be able to withstand successfully such a condition.

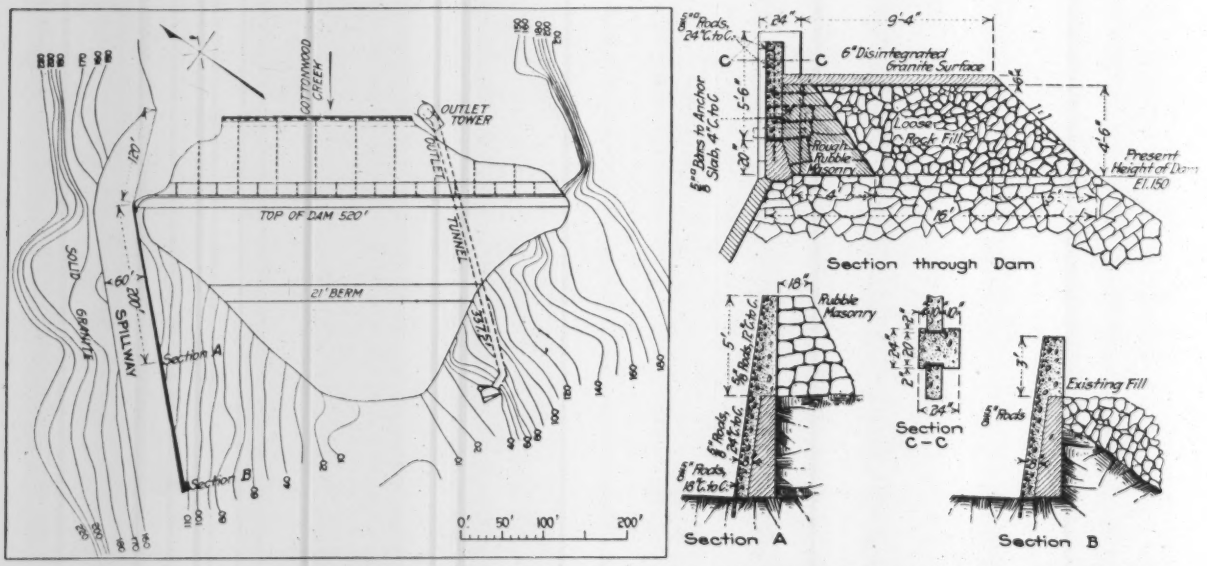
Morena is a rock-fill type of dam and was not built to withstand topping like an overflow type of dam. It might survive such a condition; but we have no right to assume this, and it would be very unwise in my opinion to do so. There are several different methods by which we can safeguard Morena dam against the danger of overflow:

1. Protect the downstream face of the dam by paving with concrete in order to prevent erosion of the face in case water should flow over the top of the dam.

2. Enlarge the capacity of the spillway by deepening or widening.

3. Raise the height of the dam and thereby increase the capacity of the reservoir and the spillway at the same time. This scheme is shown in the accompanying drawing.

4. Keep the water level in the reservoir below the 141-ft. contour during the winter months, so that the reservoir will have enough capacity to absorb any flood of the same magnitude as the one on Jan. 27, 1916, without danger of topping.



DETAILS OF PROPOSED METHOD OF ADDING 5 FT. TO HEIGHT OF MORENA DAM, SAN DIEGO WATER-SUPPLY

The first method—paving the downstream face of the dam—was eliminated because of the expense. Officials doubted if $100,000 would cover the cost. Furthermore, the dam was never intended to be an overflow type of dam.

The second method appeared to be impracticable, owing to conditions on the ground which would prevent the widening of the spillway, and to deepen it would diminish the capacity of the reservoir.

The third plan—raising the height of the dam—appeared to be the most logical. By the addition of 5 ft. to the height of the dam the capacity of the reservoir will be increased above the present spillway crest, and at the same time the capacity of the spillway will be increased to such an extent that the water level in the reservoir can be maintained at the 146-ft. contour, or the crest of the present spillway, without any danger of an excessive flood like that of last winter topping the dam.

The fourth method—maintaining a low-water level—is suggested by Mr. Cromwell as an emergency proposition only, to be followed in case no other method of protection is possible. In his report he estimates that the amount of water which would be wasted in maintaining this low level would be worth at least $75,000.

In addition to raising the dam it is planned to deepen the lower end of the spillway and thus give a steeper grade, which will carry the waste off much faster than at present. It is also planned to place a log boom in front of the spillway to prevent the choking of the entrance with floating débris.

The engineer's estimates of the work to be done at Morena are as follows:

200 cu.yd. reinforced concrete @ $20	$4,000
400 cu.yd. rubble masonry @ $8	3,200
1,000 cu.yd. loose rock fill @ $3	3,000
100 cu.yd. surfacing material @ $1.50	150
	$10,350
Engineering and superintendence, 15%	1,542
Total cost of raising dam 5 ft	$11,892

An appropriation of $15,000 is asked for the entire improvement, the balance of $3,108 to be expended for the log boom and additional repairs to the present spillway.

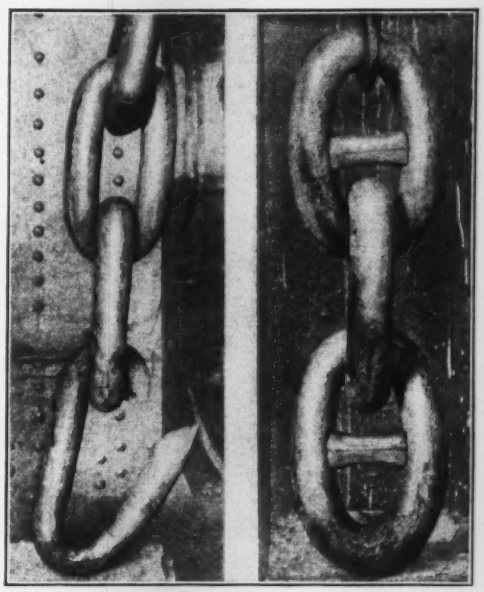
Large Chain Cables Now Power-Forged at Navy Yard*

By Frederic G. Coburn†

There has been developed, during the last two years, at the United States Navy Yard, Boston, Mass., a power-forging process for the manufacture of chain cables which has been highly successful. No great mechanical difficulty was experienced in the manufacture of chain by hand until diameters as great as 2¾ in. were reached; even that size was fairly well handled; but when the 3-in. cables were taken up, serious difficulties were encountered on account of the size of the metal, the mechanical difficulties involved and the very hard labor required of the chain makers' helpers. It was not only difficult to get chain makers to make good chain; it was exceedingly difficult to get them to attain a satisfactorily high rate of production and regularity of attendance.

When the Panama Canal Commission went into the market for the guard chains for the Panama Canal, which were 3 in. in diameter, the Boston Navy Yard was the only plant that could reasonably approach the requirements of the commission. A great part of these cables was made with open links—that is, without studs—and hence was inherently weaker than stud chain; and as the welds were not well made the ultimate breaking stresses obtained were low. Whereas 525,000 lb. ultimate breaking strength was required for stud-link chain and desired for 3-in. open-link chain, it was found necessary to reduce the requirement to 500,000 lb. and subsequently to 450,000. Private chain makers were given contracts. Their chain was not so good as that made by the hand-welders at the Boston Navy Yard; it lacked the uniformity in shape and size of link and was not so well welded.

The causes of the inferiority of hand-made welds become apparent after experience in the testing pit. The helpers can not hit hard enough with their sledges to drive the two scarfs together. The welding surfaces are not smooth, because they are formed by peening; pockets are thus formed, which retain slag; and the hammering



TWO 3¼-IN. POWER-WELDED TRIPLETS; ONE OPEN LINK, THE OTHER STUD LINK

Triplet at left broke under test at 532,000 lb. Chain at right weighs 595 lb. per fathom and runs 6 links per fathom —ultimate strength 612,000 lb.

does not work out this slag. Thus the weld is incomplete. Sometimes a pocket as big as a half-dollar is found, occasionally open to the sea by a small crevice. Fractures have been produced in proofing old chain which showed that not over 10% of the surfaces was welded; only the strength due to form, assisted by the tacking together of the scarfs, had held those links intact in service.

In the large chain it was impossible to finish the inside of the link at the welded end, thus leaving a hollow and reducing the sectional area.

Another serious defect in the hand-welded chain is the wasting of the material, in the fire, just back of the weld.

*Paper presented before Society of Naval Architects and Marine Engineers, at New York meeting, Nov. 16, 1916.

†Naval Constructor, United States Navy.

Royalties on Iron Ore taken from mines owned by the State of Minnesota amounted to $475,000 for the three months ending Oct. 1. From present indications the total ore taken from the state mines this year will exceed 4,000,000 tons, and the royalties will be in excess of $1,000,000.

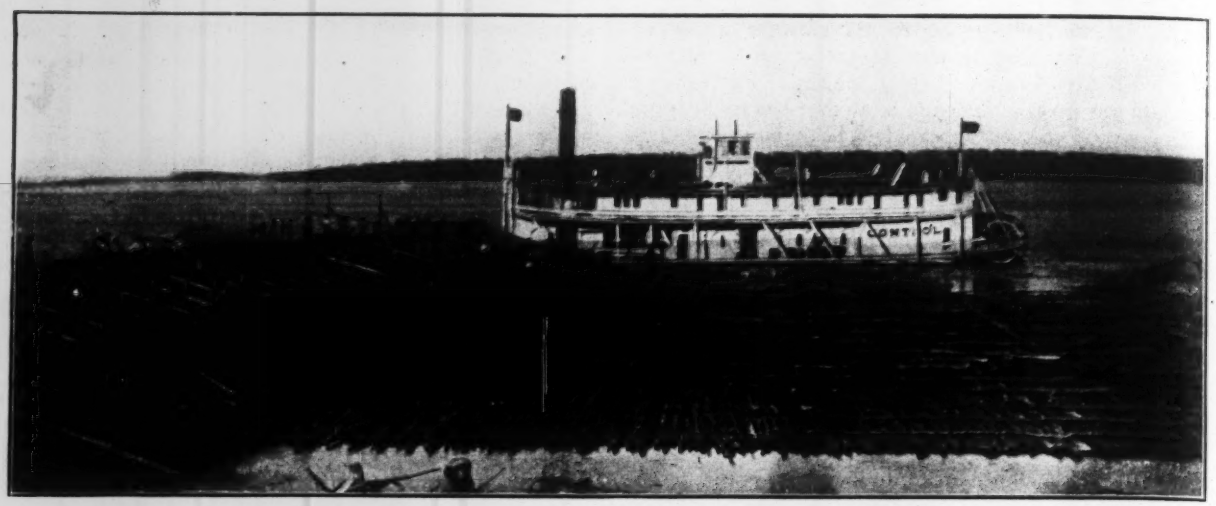


FIG. 1. WEAVING A BRUSH MATTRESS ON THE MISSISSIPPI AT PANTHER FOREST, ARK.

Five Days on the Mississippi

By Frank C. Wight*

The Mississippi River is a curiously paradoxical stream. Its variability is invariable. Year after year its enormous drainage area delivers into the sinuous channel more water than the established banks can hold and there results a flood the height of which depends on the stability of the man-made defenses. When the water goes down, notable topographical and even geographical changes are revealed. Though you never can tell just what the river will do at any one place, you can always be sure that what it does will only be a duplicate of what it has already done at the same or at other places many times before.

The control of the Mississippi partakes of this same invariability. Many years ago engineers studied the river and devised certain methods to curb its power and make habitable its alluvial valley. Those methods have persisted in spite of a perennial crop of amateurs whose schemes and plans for river control have more of novelty than of merit. These facts have become so firmly embedded in the engineer's mind that he is apt to assume that so far as Mississippi River control is concerned there can be no new thing under the sun and he dismisses the work there from his mind except at time of flood, when he may wonder why certain apparently self-evident schemes have not been utilized to better protect the rich alluvial valley. The fact is that the protection of the Mississippi Valley has within the past few years taken on a somewhat new form. The general methods have not been changed, but more modern adaptations of these methods are constantly being attempted. Because the writer knew that a number of these newer schemes were being put into effect on the Third District of the Mississippi River Commission's work—that is, the district extending from just below Memphis to just below Vicksburg—he welcomed the opportunity of making an inspection trip during the month of October with Maj. John R. Slattery, Corps of Engineers, U. S. A., the officer in charge of the district.

Possibly the best way of bringing before the engineering world these newer methods of work on Mississippi River control is to give an account of this trip. It should be understood that similar work is under way both above Memphis and below Vicksburg, and the description which follows is indicative of what is going on along the whole stretch of the alluvial valley from Cairo to the Passes.

As shown on the accompanying map, the whole of the Third District is protected by levees with the exception of the west bank on either side of the Arkansas River, and here new levees are under construction to close the gap through which high water enters to flood the territory surrounding Arkansas City, itself well guarded at its front from the direct rise from the Mississippi. Work elsewhere in the district consists in raising the old levees to a height indicated by the record flood of 1913, the construction of levee loops back of the levee lines threatened by caving banks, and the protection of banks. In all this work the distinguishing feature is the increasing utilization of machinery to replace man and animal labor and of concrete to replace wood and riprap in bank protection. In these improvements alone lies the difference in Mississippi River regulation of today from that of a quarter-century ago, and the essential elements in the new methods were all observed in the five-day trip down the 200-odd miles of river. The old levees were for the most part simple earth ridges placed by mule, negro and barrow or scraper from riverside borrow pits. The new levees are from 3 to 10 ft. higher and are widened in proportion plus the addition of a large landside banquette which adds strength and security against percolation. A

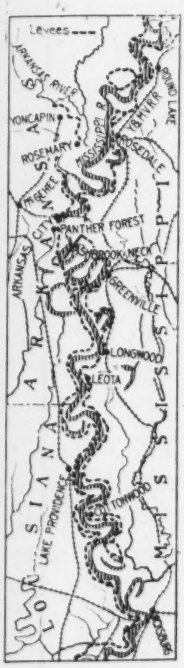


FIG. 2

*Managing Editor, "Engineering News."

few years ago the river engineers began to experiment with machines to build this enlargement—and incidentally to build new levees. The idea has so grown that now about 30 machines are in operation between Cairo and the Gulf.

The chief difficulty in the use of such machines is to find a place within reach of the machine where sufficient earth can be excavated. Already the riverside pits adjoining the levee are as deep as safety permits. To dig on the land side is objectionable for numerous reasons, although allowable under extreme conditions. How the various machines at work in the Third District meet the requirements is set forth here. There has also been prepared (Fig. 4) a sketch drawn to scale showing the general conditions under which the machines in the district are working.

The Lidgerwood Cableway Near Round Lake

The first place visited was the stretch of levee elevation in the vicinity of Round Lake, reached from Memphis via the oft-flooded Yazoo & Mississippi Valley R.R.

FIG. 3. CAVING BANK IN BRUSH MATTRESS BELOW CONCRETE BANK PAVING

Here is operating the Lidgerwood cableway described by Major Slattery in his article in *Engineering News*, May 25, 1916, p. 986.

The old levee here was 21 ft. high and had no banquette, and it had been built from borrow pits on the river side. After the 1913 flood it was determined that the tentative grade to which levees prior to that year were being built was from 2 to 3 ft. too low, and a general raising of the system to a new grade was therefore decided upon. It was also decided that the time had come to take up on a more general scale the construction of banquettes, as the system had reached a development that rendered it safe against all but extreme floods. The new height thereafter was decided upon of 24 ft., with the addition of a heavy banquette on the land side. The old and new sections are about as shown in Fig. 4.

For numerous reasons—partly because of the unsightliness of landside borrow pits and partly because of unhealthy conditions arising from the stagnant mosquito-breeding water sure to collect in them, but mainly because of the reduction in the strength of the levee by landside excavation—it was decided that the extension of the levee should be made from dirt dug from the river side. But the old pit there was so deep, so wide and so saturated with water as to preclude the use of any ordinary machine and to make the haulage by animal power rather expensive. For these reasons the Mississippi River Commission purchased a new taut-line cableway excavator from the Lidgerwood Manufacturing Co.—a machine designed especially for this location.

The machine has a 3-yd. scraper bucket which digs in a limited area and is then lifted, carried through the air and dumped on the levee from a height of 10 to 40 ft. There are two movable steel towers about 660 ft. c. to c., the head tower being located entirely to the land side of the levee and the tail tower entirely to the river side of the borrow pit. The digging is all done beyond the old river end of the riverside borrow pits. The whole levee enlargement can thus be built in one operation from new ground on the river side, and this is the only machine on the river capable of doing this. With this machine as in all others, final smoothing of the surface has to be done by hand labor.

On account of some difficulties in maintenance, particularly because of an inexplicable rapid wear in the main cable, the machine has not been performing quite so well during the past summer as it did in the summer of 1915, as recorded in Major Slattery's earlier article. It is, however, digging now at about 19c. per cu.yd., which is probably considerably cheaper than the work could be done for by contract, using the old method of teams and scrapers. It is also claimed that the riverside conditions—that is, the extreme conditions of moisture and water in the borrow pit—make it practicably impossible to utilize any other machine at this location.

Government Camps Clean and Sanitary

The whole outfit is owned by the Government and operated by Government forces, and the camp showed the salutary effect of Government supervision. The tents are all of a special type devised by Major Slattery and built at the Government shop at Vicksburg. They are in effect portable houses with tent tops, consisting of screened side frames with canvas tops and provided with wooden floors and screen doors. The night-flying malar-

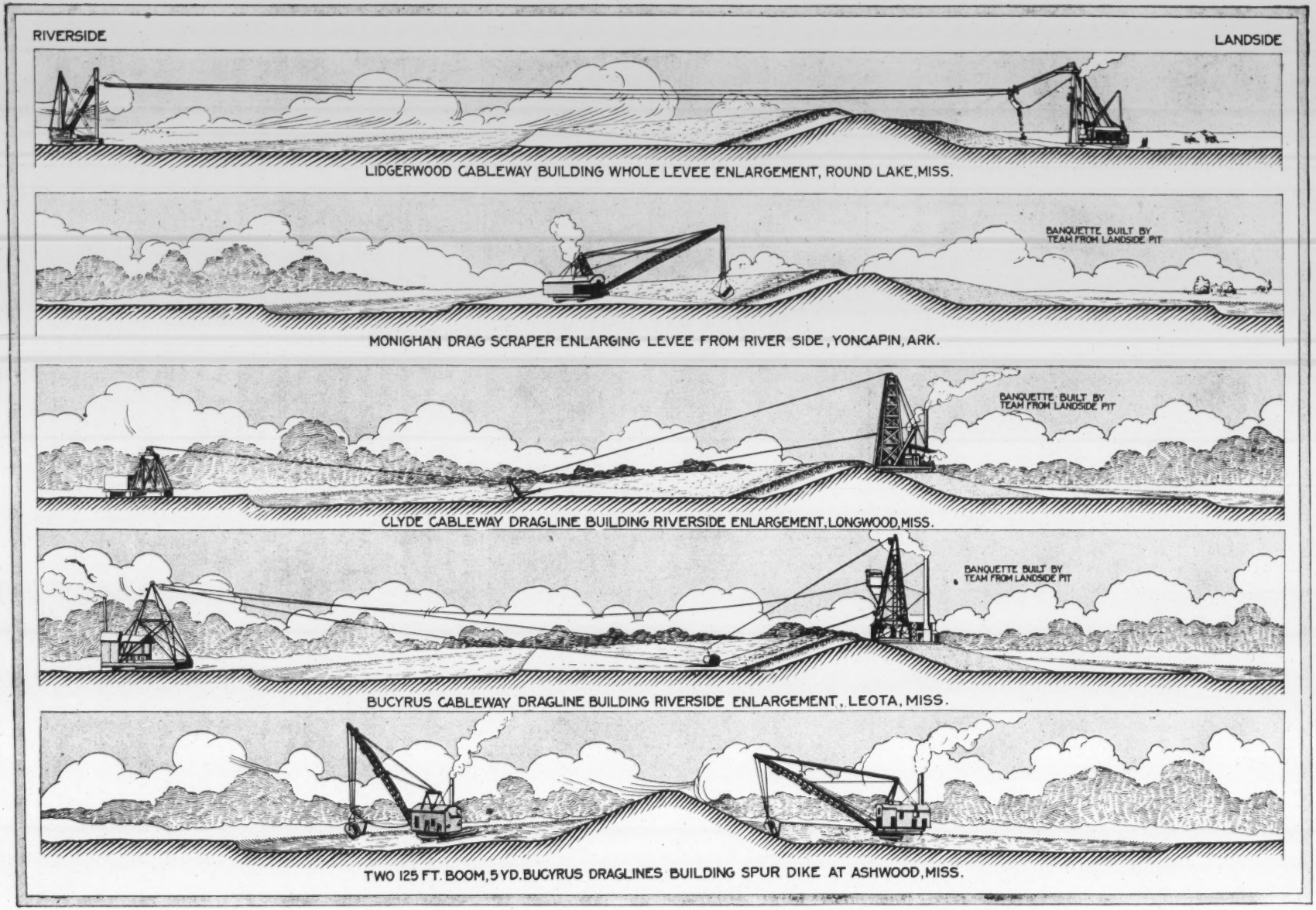

RIVERSIDE
LANDSIDE
LIDGERWOOD CABLEWAY BUILDING WHOLE LEVEE ENLARGEMENT, ROUND LAKE, MISS.
BANQUETTE BUILT BY TEAM FROM LANDSIDE PIT
MONIGHAN DRAG SCRAPER ENLARGING LEVEE FROM RIVER SIDE, YONCAPIN, ARK.
BANQUETTE BUILT BY TEAM FROM LANDSIDE PIT
CLYDE CABLEWAY DRAGLINE BUILDING RIVERSIDE ENLARGEMENT, LONGWOOD, MISS.
BANQUETTE BUILT BY TEAM FROM LANDSIDE PIT
BUCYRUS CABLEWAY DRAGLINE BUILDING RIVERSIDE ENLARGEMENT, LEOTA, MISS.
TWO 125 FT. BOOM, 5 YD. BUCYRUS DRAGLINES BUILDING SPUR DIKE AT ASHWOOD, MISS.

FIG. 4. SKETCHES TO SAME SCALE SHOWING DIFFERENT METHODS OF BUILDING LEVEES WITH MACHINES IN THIRD DISTRICT, MISSISSIPPI RIVER

ial mosquito, whose activities were very evident in the pallor and languor of a number of the men we saw farther south, has a hard time getting at the Government engineer or laborer who stays inside of his Government-provided tent.

Furthermore, the camp at Round Lake had a cleaner and better-ordered aspect than some of those farther down the river, although of course some of the contractors observe the amenities of sanitation better than others. Taking it by and large, the negro laborers' camp is a pretty dirty place both morally and physically, so that the Government's efforts to clean up those which are under its charge are greatly to be commended.

At Round Lake we first saw the operation of sodding a levee, a common enough sight to those acquainted with Mississippi River work, but strange to the newcomer. Sodding consists in punching holes on 2-ft. centers on the side of the levee and depositing a few blades and roots of Bermuda grass in the holes thus made. It would apparently require the utmost optimism to hope that such a scanty distribution of these tiny plants would ever have any effect; but farther along we saw many miles of levee well covered with grass which had grown from just such a sparse planting.

Leaving Round Lake by team, we drove about a mile to the river, where we took up our week's quarters on the U. S. S. "Control," a sturdy, well-built, well-equipped sternwheeler which the Third District uses for inspection trips, surveys and tows. The river was near its lowest stage—about 6¾ ft.—which is some 50 ft. below the record flood height here. This meant that all bank protection work was exposed far down the mattress, that the banks themselves were high above the water and that the levees were all a mile or more inland. One realized the size of the river in flood after clambering up 20 or 30 ft. of slipping bank, walking two miles inland through cottonwood forests and cotton fields, and coming to a 20-ft. levee carrying on its top a pile of coal left for the excavators by a towboat during the last high water!

The first night we made a three-hour run down to Rosedale, the only night traveling done during the week. Navigation by night during a low-water period is not always soothing to the nerves, if the snag which we struck about an hour after we left Round Lake is any evidence. Collision with other vessels, however, need hardly be cause for worry, for in the five-day trip only *one* commercial steamer was sighted and that one was within rifle shot of Vicksburg.

Beulah Crevasse as It Is Today

Early next morning we started out from Rosedale in the omnipresent Ford, the only vehicle extant that can negotiate the Mississippi River roads. This particular machine was driven by an African aborigine who from appearance and clothing was only a few days removed from the Congo jungle, but who in time of stress could baby the engine with a facility equal to that of the best French chauffeur.

So conducted, we proceeded to the Beulah levee, made famous by crevasses in 1912 and 1913. Just about the site of the crevasses we saw our first teamwork. Here a few negroes and mules with drag scrapers are raising another levee to meet the new flood requirements. The camp reached the nadir of uncleanliness, and the men and mules both showed signs of wear.

At Beulah itself the record of the crevasse can be read in the eroded land area. The whole territory on the land side is deserted because of the two floods. The remnants of the closing trestle are visible at places about the earth-fill. Along here, too, is what is known as the worst place on the Mississippi River. For a stretch of about 300 ft. the levee has literally dropped about 100 ft. and is sinking pretty nearly vertically at odd distances and odd times, while a bulged surface shows up far inland. It has cost the Government over $50,000 to bring the levee to its present level, and still there are signs of further subsidence, showing that the trouble is not yet over. Further enlargement of the levee is planned for the immediate future.

Up the Arkansas River

It had been planned to go up the Arkansas River in the boat to see the work there, but the extremely low stage prohibited this. There was in fact, tied up to the bank at Arkansas City, a packet which was drawing at the time only 18 in. of water, but which was held up from its customary trip up the river on account of prohibitive shoals. Instead of making the trip by boat, we took a train at Arkansas City, which might be called the Venice of America during three or four months of the year if one may judge from the mud lines that show about the top of the first-floor windows on all the houses.

The train took us to Yoncapin, on the Arkansas River, where the levees of that district are being raised. Here we saw two Monighan dragline boom scrapers raising the old levee from its elevation of 15 ft. to a new elevation of 20 ft., with a landside banquette (Fig. 4). This banquette, requiring about 1,800 cu.yd. per station, had to be built by separate excavation from the land side, while the elevation of the levee was done by excavation from the river side. The machines have been rebuilt so that each now has a 125-ft. boom and a 3-yd. bucket, which picks up the earth from the riverside borrow pit and swinging in a circle, dumps it on the levee. The contractor is getting about 12c. per cu.yd., which includes in one case the construction of a banquette, as previously noted, and in the other the construction of whole levee enlargement by a double handling of the work. In this stretch the borrow-pit area was heavily wooded and timber clearing was going on ahead of the machine. On another contract in this vicinity, another Monighan machine, which is working on trucks (the first two were working on rollers), is building a similar section of levee. This machine had to move three times to get the material to its proper place. The contractor is getting 14c. per cu.yd.

Still farther down the river is the scene of the Rosemary crevasse of last year, where teams are hauling earth from borrow pits in a wooded tract on the river side to fill up a 3,000-ft. break as an emergency job. As indicative of the difference in cost between machine and mule work, the contractor here is getting 25c. a cu.yd. The negro camp was characteristically bad.

On the way back to the boat, 30 mi. by Ford, we stopped for a time to see the setting up of an old Lidgerwood machine, which is about to go to work on the lower Arkansas River levee, where it will join the Mississippi levee and close the gap that now lets the water down on Arkansas City. This machine, operated from cableway, is one that was first used at the Sag canal enlargement

for the Sanitary District of Chicago, then went into the Detroit channel work and finally to the New York Barge Canal at Rome. It still appears to be good for many yards of excavation. It will operate in practically the same manner as the other Lidgerwood machine at Round Lake.

Bucyrus Draglines Build Spur Dike

We reached the boat about noon and headed down the river for Ashbrook Neck, where two of the most modern machines on the river are being operated. Ashbrook Neck is a peninsula forming one of the famous Arkansas City-Greenville bends. For a number of years the bank has been caving at the narrow neck of the peninsula, now only 1,800 ft. across, at the rate of about 200 ft. per year, and the time is fast approaching when it would cut through and shorten the river about 6 mi. It is characteristic of the Mississippi that if it is shortened, it will attempt to make up its length some way or other; and if the Ashbrook Neck were cut through, there would be imminent danger of serious trouble at Greenville, at the foot of the bends. For this reason during the last year the commission decided to extend out onto the neck from the levee at its base a so-called spur dike of earth, and at the same time to revet the banks to retard the caving.

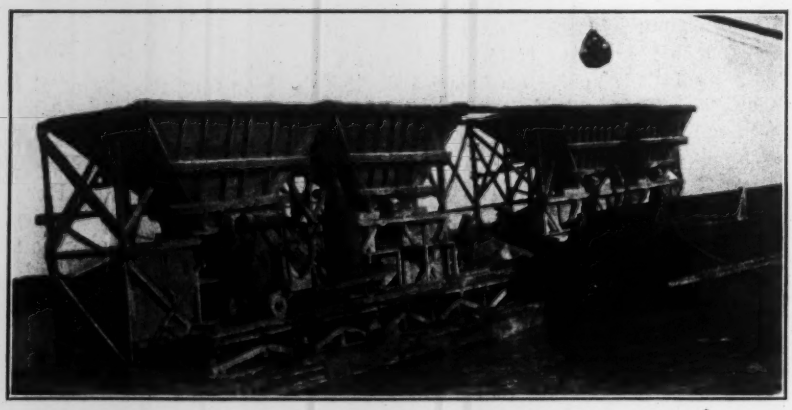


FIG. 5. CONCRETE MIXING PLANT USED ON BANK PAVING WORK

This new spur dike will be about 5 mi. long and will extend out to within 15,000 ft. of the other side of the river. It is an earth-fill from 21 to 35 ft. in height, with side slopes of 1:2½, and a top of 6 ft. It will be paved for some distance near the end on the side exposed to the flood current with 4 in. of concrete paving, which will extend down into a riprap-filled gutter at the river base. The end of the dike is curved to about right angles to its length, and the pavement will extend around the curved end to the straight portion.

To guard further against scour along the upper side of the dike, a system of permeable brush dikes will be constructed wherever the material is such as to be in danger from scour.

This dike is being built by the Government with two special Bucyrus locomotive-crane dragline excavators, with 125-ft. booms and 5-yd. buckets. These machines are working their way down through the wooded territory of the neck (Fig. 4), one machine on each side. The trees in front are cleared out by contract, and the two huge excavators working on tracks on 15-ft. sections move down the cleared space at the rate of about 130 ft. per day. The track is skidded along by the power of the machine. The ground is almost like brown sugar in its consistency and the machines, during the hours that we were there at least, worked to perfection. There will be about 1,750,000 cu.yd. of dirt in the spur dike, and the cost will be about $275,000. At present, however, the fill is being made at the rate of about 6c. per cu.yd. The machines now make from 1,500 to 3,000 cu. yd. per 20-hr. day.

Later in the day we stopped at Panther Forest, Ark., one of the worst caving banks on the river, where a willow mat (Fig. 1) was being woven. Repeated laying of mats here does not seem to prevent the caving, which shows up after every flood water.

How Concrete Bank Paving Is Built

Just above Greenville, where we tied up for the night, we saw the next morning our first concrete bank paving, a stretch of which had been in place for about a year. It was in remarkably good shape after having passed through one high water and, although in places covered with the alluvial deposit from the flood, still was intact except in a few places where the joint connection between the paving and the willow mat seemed to allow opening enough for erosion to start. In one particular place, a view of which is shown in Fig. 3, the cave has occurred in spite of the paving and the mat, but it will be seen from the view that this caving was confined to a small area, whereas if there had not been good protection, it probably would have extended along quite a distance. The paving is of unreinforced concrete 4 in. thick. It is laid directly on a 1:3 slope of the river bank, the slope being made generally by a hydraulic giant. It is laid without any joints and only above the willow mat, opportunity being taken at low water when this elevation is exposed. It follows the convolutions of the ground as it is smoothed up after the hydraulic giants work it to a fairly even slope.

The machine by which this paving is laid is shown in the view in Fig. 5. It is an ordinary barge on which are mounted on one side a series of elevated bins; down the middle a low trestle on which is a track for the concrete mixer, and on the other side a still lower track for the concrete car. The bins are filled up with river gravel by clamshells working from an adjoining derrick boom. Cement is loaded into the spaces underneath the gravel bins.

These bins, as shown in the view, have hopper openings, and the mixer can be run along the track to any one of the openings, and the car can be run on its lowest track to take the discharge from the mixer and to reach the derrick boat, which swings it into place on the river bank. The concrete is laid within reach of the derrick boat by merely dropping from the boom. Above that height wooden tracks, made up of 4x6's and tied together in 8-ft. sections, are laid up the bank and a car filled from the derrick is pushed up to dump clear to the top of the bank, where a 6x12-in. curb is let down

into the bank to insure stability. Such work costs from 2¾ to 5c. per sq.ft., the lower cost not giving such good results and the higher a little too good. It is estimated that for 4c. per sq.ft. very good paving can be laid. This is about one-half the price of the riprap which it replaces. The gravel will make a concrete than runs about 1:3:6. It is not perfect concrete by any means, but it seems to be quite good enough for the purpose.

Clyde and Bucyrus Dragline Tower Excavators

Later in the day the boat stopped at Longwood Landing, Miss., and a 3-mi. walk brought us to the levee enlargement work there. Here the contractor gets about 14c. per cu.yd. for enlarging the levee from the river side, the banquette having been built the season before with teams, borrowing from landside pits. The machine used is a tower scraper of the slack-line cableway type, built under the Field patent by the Clyde Iron Works (Fig. 4). It is making from 900 to 1,500 cu.yd. per day of 12 hr., but on account of various difficulties, mainly logs and saplings in the ground, it rarely works over 9 hr. The span is about 500 ft., and there is a bottom-dump bucket of 5 yd. capacity on the machine. The tail tower is a low moving stand. At this particular place there is some difficulty because the banquette as built is not wide enough to carry the machine and a trench had to be dug into the side of the levee to carry the inside tracks. This is bad because every effort is made in the Mississippi River levee work not to disturb the integrity of old levees.

After going back to the boat again and traveling down the river some few miles, we came to Leota, Miss., where a 10-mi. levee enlargement is being made with a Bucyrus tower dragline scraper (Fig. 4), also of the slack-line cableway type, which uses a 6-yd. bucket that can be enlarged to 8 yd. by sideboards. The head tower is self-propelling, as are also the tail towers. It operates on the banquette, which has to be built ahead by hand-work excavated from the land side. The cableway has a span of about 500 ft., and the drag-scraper when piling up the front and top of the levee seems to be most successful, the cost now running pretty close to 11c. per cu.yd. Such compacting as the levee gets in all these dragline machines is due solely to the dragging of the heavily loaded bucket up the slope. There is no dropping the earth from a height, as in the Lidgerwood tautline machines.

Mississippi River Work in Epitome

The next day we came to Cottonwood Landing somewhat farther down the river, where is now going on the most spectacular work on this stretch of the river. Everything of Mississippi River protection work is in sight at Cottonwood. On the river side a number of men are weaving a willow mattress. Farther down the stream a hydraulic jet is cutting down the bank to prepare the slope for the concrete paving, which is being placed on the slope already reduced, and back 500 ft. or more from the river a multitude of teams and men are building a new levee to take the place of the one that was destroyed as a result of violent bank caving after the flood of last year. A year ago this levee was 1,500 ft. inside the river, but when the water went down last spring, the bank caved back for 1,500 ft. and the levee slid into the river.

FIG. 6. TEAMS AND ELEVATING GRADERS BUILDING NEW LEVEES AT COTTONWOOD, MISS.

The levee work here is under three contractors, and it is of the highest type of mule and man construction. The camps appear to be fairly decent, and the operation of the work is very scientific. Practically all the earth is being placed with four-mule teams loaded from elevating scrapers and carried up to dump on the high levee slope (Fig. 6). The whole outfit comprises about 400 teams, 10 elevating graders, 150 1½-yd. wagons and wheel scrapers, all made by the Western Wheel Scraper Co.

The total yardage of this work is about 600,000 cu.yd. The promptness with which an empty team draws up to the scraper just as the old team is filled and leaves and the very little loss of time in this operation testify to efficient administration of the contract. It is emergency work, for the gap must be closed before high water, so the contractors are getting a good price.

On the afternoon of the fifth day out from Round Lake we steamed up the narrow Yazoo Canal to the end of the trip, the Government wharf at Vicksburg, where the construction and repair work for the district centers.

Vibrating Concrete Makes Dense Paving Mixture

For the purpose of obtaining the densest possible concrete for street pavements, a method of construction in which the layer of green concrete is gone over with gasoline-engine vibrators has been devised and patented by R. C. Stubbs, of Dallas, Tex. Several Texas cities have laid pavements under this specification in the last six years, and during the past month two "Vibrolithic" pavements have been completed in White Plains, N. Y., the first to be constructed in the East. Dallas, Tex., has the largest yardage; contracts were recently made at a single letting for 100,000 sq.yd. of this type of pavement.

While the use of the vibrator is the principal feature in the construction of this pavement, there are other noteworthy points in the method. Up to the time when the concrete has been mixed and placed on the roadbed the specifications and method of construction do not differ from ordinary good practice, except that the mix is somewhat drier than usual. But immediately after placing, raking and smoothing the freshly placed concrete to the true grade there is spread over the surface a coating of trap rock or granite (passing a 2-in. and retained on a 1-in. screen) to a depth of between 1 and 2 in. On this surface are then laid narrow flexible board platforms, the boards being laid parallel to the center line of the pavement. On these platforms the vibrators are rolled.

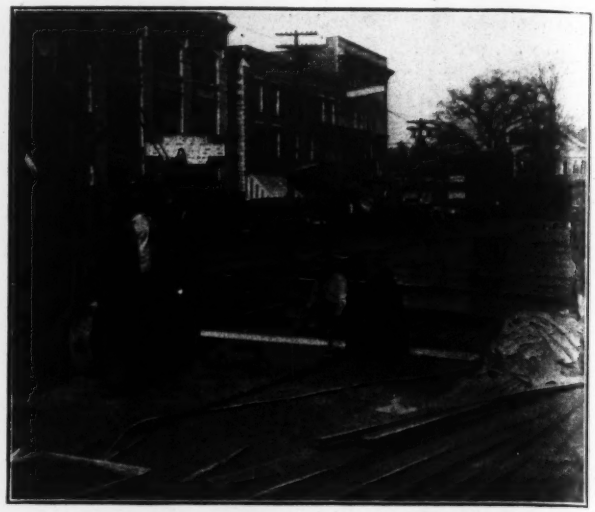


FIG. 2. SHOWING JOINT CONSTRUCTION OF "VIBROLITHIC" PAVEMENT

The result of this vibrating or quaking is of course to force the surfacing of broken stone into the concrete and to flush out the surplus water and mortar. The vibrating is based on the theory that the mortar is the weakest part of the concrete, and where density is equal, the strength of the concrete varies inversely with the dis-

FIG. 1. CONSTRUCTING A "VIBROLITHIC" CONCRETE PAVEMENT AT WHITE PLAINS, N. Y.

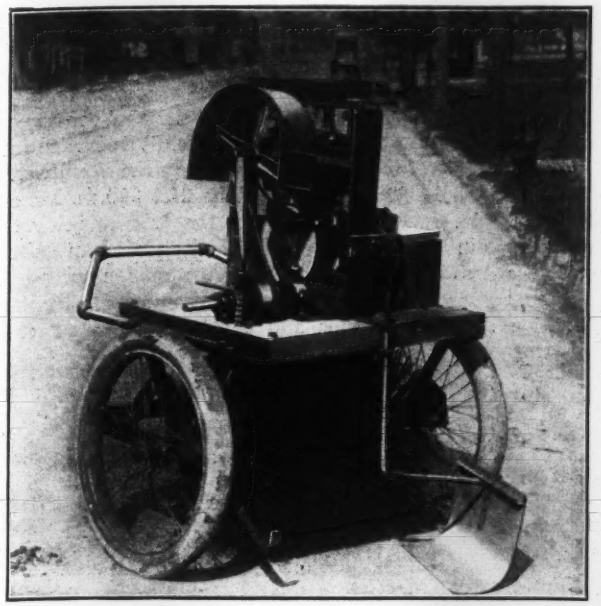


FIG. 3. POWER BROOM USED ON CONCRETE ONE OR TWO DAYS OLD

tance between the pieces of coarse aggregate; that the thinnest possible film of mortar between the stones, provided all the voids are filled, gives the strongest bond and is the ideal condition. Moreover, the denser the concrete the less the absorption of moisture and the less the subsequent expansion and contraction.

The pavement is laid without expansion joints at the curbs, but with transverse and longitudinal joints of ½x3-in. boards left in the bottom half of the pavement, as shown in Fig. 2. These divide the pavement into slabs 30 ft. long by half the width of the pavement. The upper 3 in. of the pavement, however, is monolithic, the joints merely being designed to form vertical planes of weakness where the slabs will crack uniformly instead of irregularly, if they crack at all.

After the concrete is a day or two old a high-speed revolving broom (Fig. 3) is passed over the surface, and any laitance and surplus mortar is removed, leaving a clean hard stony surface. On this surface is immediately spread a hot tar carpet, covered with pea stone or grit.

The object of the tar carpet is chiefly to protect the concrete during the curing process. It is designed to retain the moisture in the concrete until a complete set has occurred and to save the green concrete from the abrasion of traffic. The tar carpet is claimed to make it unnecessary to keep the concrete dampened or covered with water or earth, as in ordinary practice.

The distinguishing feature of construction, the use of a vibrator, unquestionably produces a very dense concrete. Pieces broken out of old pavements show the stones in close proximity to each other and a smooth, flinty plane of cleavage characteristic of a dense and thoroughly hydrated concrete. Both the vibrator and the process involving its use are patented. The machine itself is merely a 4-hp. motor-cycle engine mounted on a steel frame with steel roller wheels, as illustrated in Fig. 4. The pulsations of this unbalanced engine are about 1,000 per minute.

FIG. 5. CONSTRUCTION VIEW SHOWING BROKEN STONE ON GREEN CONCRETE READY FOR VIBRATING

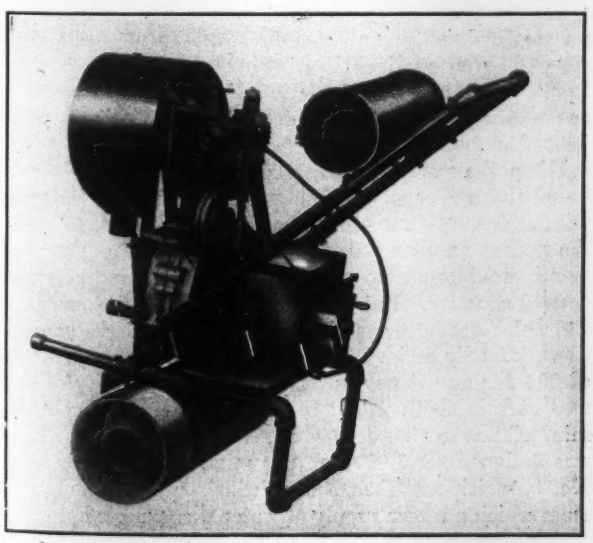


FIG. 4. PATENTED GASOLINE-ENGINE VIBRATOR

The developer of this method of construction sums up its advantages as follows: The vibrations produce density in the entire mass, permit the economical addition of broken stone in the upper portion of the slab and bring to the surface a rich dense mortar to bind the added stone, while the stones being at or near the surface form the ultimate wearing surface. The seal coat of tar covered with pea stone, chats or torpedo sand forms the temporary wearing surface, improves the looks of the pavement, makes it noiseless, gives it a nonskid surface and aids in the uniform curing of the concrete.

The patents are controlled by a central organization, the American Vibrolithic, with present headquarters at Dallas, Tex. The intention is to allow the pavement to be laid by any reputable concrete contractor on the payment of a royalty. The work on Mamaroneck and Howard Ave., White Plains, N. Y., shown in the accompanying illustrations, was done by E. L. Erbeck, contractor, under the general supervision of Frank W. Sampson, Katonah, N. Y., Eastern representative of the American Vibrolithic. The contract price of these pavements was $1.85 per sq.yd.

Well-Unit Water-Supply at Aurora, Ill.

SYNOPSIS—The city's principal water-supply is obtained from a group of deep wells at the water-works. To increase the supply, wells have been driven in different parts of the city, having their own electric pumping plants so as to form independent units. Auxiliary pumps provide for increasing the pressure in the mains in case of fire. The results of pumping tests on the wells are given.

To provide a necessary increase in the capacity of the water-works of Aurora, Ill., the city has adopted the well-unit supply system. This consists of a number of deep wells distributed throughout the city, each operated by independent pumping units that deliver the water directly into the mains. In planning the system the wells are so located that the water pumped at each point has the shortest possible travel before being consumed, thus reducing to a minimum the friction loss in the mains. For this reason wells are located usually near street intersections, so that water can be pumped in four directions.

The City of Aurora secures its water-supply from wells sunk in the St. Peter and Potsdam sandstone, and for a number of years it has pumped all its water from a group of five wells at the water-works plant in the north part of the city, on the east bank of the Fox River. With the rapid increase of population in the past few years it became necessary to secure an increased supply of water. After an investigation of the situation the city officials decided that instead of sinking more wells near the water-works it would be advisable to adopt the well-unit system.

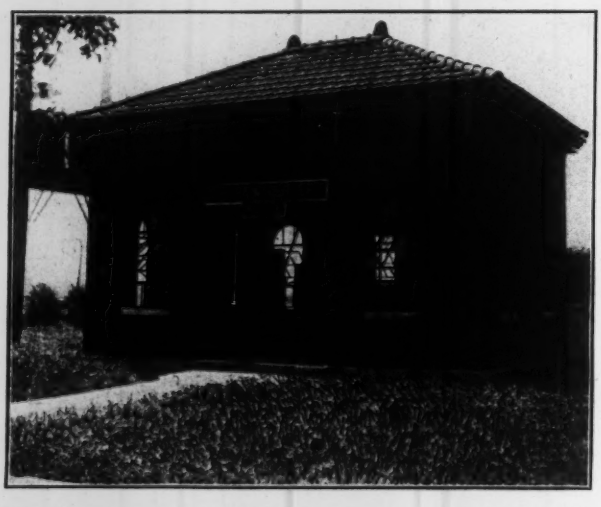


FIG. 1. PUMP HOUSE FOR WELL-UNIT AT TALMA ST., AURORA, ILL.

Progress of New Work

At present three of these new wells have been drilled. The first (known as well No. 6) is located at the corner of Talma and Binder St., in the southeastern part of the city. The second (No. 7) is in River St., in the southwestern part of the city. The third (No. 8) is located in the central part of the city, on an island in the Fox River.

Well No. 6 is 2,200 ft. deep. The first 300 ft. has a casing 18 in. in outside diameter, the balance being a 15-in. hole in the rock. In 1914 the city placed an order with the American Well Works, of Aurora, for pumping machinery for this well. The contract called for a combination deep-well turbine and booster pump for a capacity of 1,000 gal. per min., taking water at an elevation of 100 ft. below the surface of the ground and pumping against a pressure of 65 lb. at the surface. The unit was to be directly connected to a 125-hp. 440-volt two-phase 60-cycle vertical slip-ring motor running at 1,200 r.p.m. This had an automatic self-starter, with no voltage release and overload protection, and resistance with 50% full load at start.

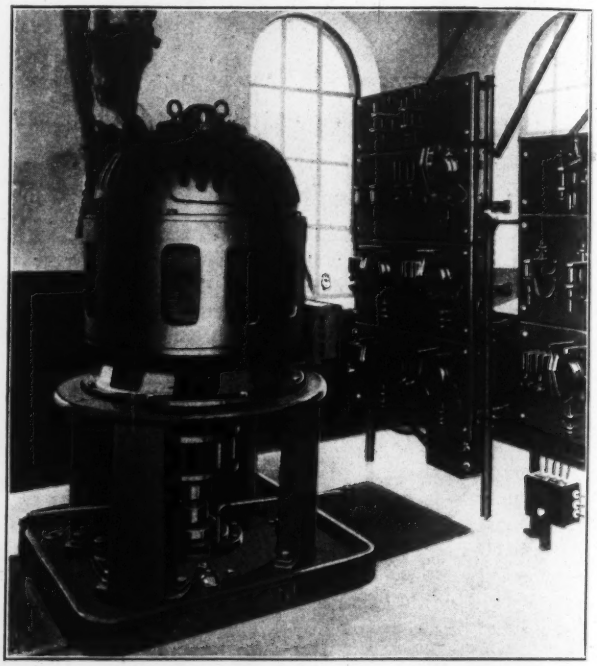


FIG. 2. INTERIOR OF PUMP HOUSE FOR WELL-UNIT SYSTEM

When the pump was installed, in May, 1915, it was found that the capacity of the well was only 240 gal. per min. at the 100-ft. depth. The city then decided to lower the turbine another 100 ft., thinking that as the well was new it would open up and flow more freely and give the desired capacity. But the capacity was only increased to 440 gal. As the demand for water exceeded the supply, the city finally decided it would pay to pump from a depth of 304 ft.; and it was estimated that the capacity of the well at this depth would be approximately 550 gal. per min. It was further decided to remove this turbine, which was designed for 1,000 gal. per min., and use it in well No. 8, which was then being drilled on the island, and from which a larger supply of water was expected.

A new unit of heavier duty was then ordered for the Talma St. well, No. 6. This is an "American" combina-

tion deep-well turbine and booster pump, provided with 38 lengths (8 ft. each) of 10-in. supporting pipe, shafting and bearings, and 40 ft. of 9-in. suction pipe. The line shafting is of 2-in. nickel steel. The lineshaft and turbine bearings are of the "oilless peg" type for water lubrication. The impellers and diffusers in both turbine and booster are made of bronze. This pump was designed to discharge 550 gal. per min. against a total head of 497 ft. when running at 1,150 r.p.m., on which was guaranteed an overall efficiency of 58% when using the 125-hp. motor.

The makers' diagram of the results obtained on the test shows that the pump delivers 650 gal. per min. against a total of 497 ft., with an overall efficiency of 61%, and 800 gal. per min. against a total head of 416 ft., with an overall efficiency of 56%. The quantity of water in this test was measured by a weir and checked by the city's water meter. After the official test, another test was made with the pump discharging directly into the mains. This showed that the pump discharged 630 gal. per min. against a total head of 497 ft. when running at 1,172 r.p.m., with an overall efficiency of 61%, and 750 gal. against a total head of 446 ft. when running at 1,167 r.p.m., with an overall efficiency of 59½%; that is, the pump had a range of from 450 gal. per min. at 556-ft. head to 750 gal. at 446-ft. head, with an overall efficiency of not less than 59%, which is 1% above the guarantee.

The River St. well (No. 7) was completed in 1914. The first 300 ft. has 18-in. casing, the balance being in rock, 15 in. inside diameter, to a depth of 2,262 ft. In January, 1915, the city bought an "American" pump (with impellers and diffusers), to have a capacity of 1,000 gal. per min. from an elevation 100 ft. below the surface. This unit was to be directly connected to a vertical 150-hp. motor having an automatic starter complete with no-voltage release and overload relays arranged for 50% full-load start. This installation is shown in Fig. 3.

To increase the pressure up to 105 lb. in the mains for fire purposes, this vertical deep-well unit will work in series with an "American" single-stage double-suction horizontal centrifugal pump directly connected to a 40-hp. slip-ring motor running at 1,800 r.p.m.

The pumps were installed and when tested the well would supply only 640 gal. per min., the water being lowered to 125 ft. from the surface, which was 25 ft. lower than the contract called for. The city therefore decided to lower the pump another 100 ft. The pump was again tested by the builders, and tests were also made by D. H. Maury, consulting engineer, Chicago. The results of the tests are summarized in tabular form and attention is called to the fact that the supply of water did not equal the capacity of the pump.

	Builder's Test	—D. H. Maury's Tests—	
Discharge, gal. per min.	930	896.0	981.0
Total head, ft.	424	426.6	410.6
Speed, r.p.m.	1,145	1,155.0	1,155.0
Pump efficiency, %	74½	70.4	70.1
Combined efficiency, %	....	62.7	62.8

This unit is similar in construction to that furnished for the Talma St. well (No. 6). Fig. 3 is a cross-section showing the construction of the combined deep-well and booster pump furnished for well No. 7. It will be seen that these units are provided with water-cooled vertical roller guide-bearings in the upper frame, and water-cooled roller thrust bearing. The booster and turbine proper both have bronze inclosed impellers, removable bronze diffusers and removable bronze wearing rings.

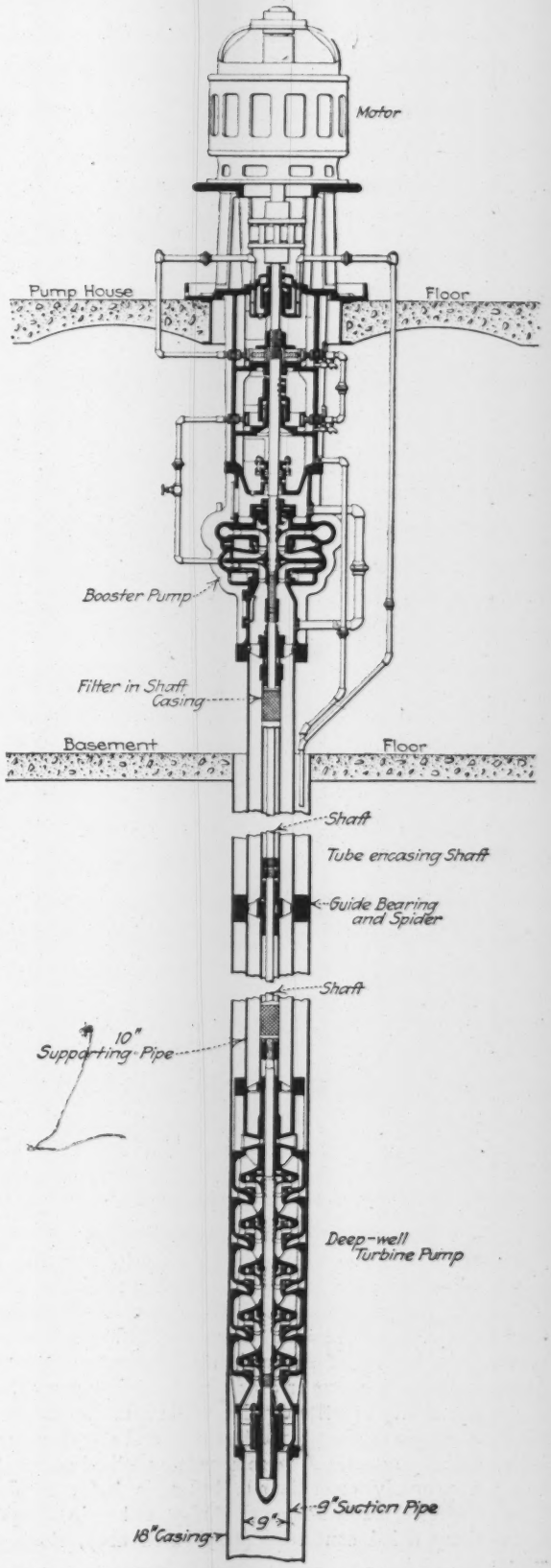


FIG. 3. DEEP-WELL PUMPING UNIT WITH TURBINE AND BOOSTER AT AURORA, ILL.

The method of lubricating the long vertical line shaft that drives the lower pump is peculiar to deep-well turbines built by the American Well Works. The line shafting is surrounded or incased in a sectional tube. The sections are fastened together by the line-shaft bearing, and the whole shaft casing is put under tension and steadied by spiders at the bearings, to make it rigid. The top length of shaft casing is provided with a filtering means, which allows part of the water pumped to enter the shaft protecting casing after it is filtered. Passages are provided through each bearing to allow the lubricating water to circulate downward and out into the well through ports in the top of the lower pump. This method of lubrication prevents contaminating the drinking water with oil or grease.

The island well (No. 8) was completed in September, 1916. The first 200 ft. has 18-in. casing, and the hole is then 15 in. in diameter to a depth of 2,305 ft. As before stated, the pumping unit originally installed in well No. 6 is to be used at this station.

Each pump house is a brick building with a basement; one is shown in Figs. 1 and 2. The current is purchased.

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Activated-Sludge Results at Cleveland Reviewed--II

By R. Winthrop Pratt* and George B. Gascoigne†

SYNOPSIS—A previous article described the plant in outline, the changes made in it since put in operation, and gave the clarification results obtained. This article deals with the ever-persistent sludge problem.

Sludge Disposal

The Cleveland tests indicate that at large plants the most important question with the activated-sludge process is an inoffensive and economical disposal of the sludge. This phase of the problem is particularly serious, as the two lake-front plants are located in residential districts and because this method of treatment produces excessive unit quantities of sludge. Consequently, particular attention has been given to the tests pertaining to the disposal of the sludge.

The schedule of operation as regards sludge disposal is divided into three stages, the first of which consists of changing the sludge to a comparatively stable condition. The material is then ready to pass through the dewatering or second stage without causing any objectionable odors even if the process should be delayed two or three days. The third stage consists of the final disposition of the material. As a preliminary step to the above-mentioned stages, tank concentration of the sludge may be desirable. The few tests so far conducted establish the idea of concentration by settling and the importance of especially designed tanks for the purpose.

Two Kinds of Activated Sludge

Activated sludge as known on the Cleveland work is of two kinds—plain and reaërated—the distinguishing feature being longer aëration for the latter. Both sludges have a chocolate color and a spongy and fluffy texture. At present the means of determining whether or not the plain sludge is in a proper condition is by its appearance, smell, and ability to settle rapidly, while with the reaërated sludge a sample is placed in a test tube and any change in color carefully noted. A more accurate method of identifying a properly conditioned sludge is badly needed. Upon standing, plain activated sludge, either in a liquid or partially dried condition (80% moisture), starts to decompose and in from 24 to 48 hr., depending upon the moisture content, will produce objectionable odors. If the sewage aëration period is lengthened to the point where stability obtains, this objectionable decomposition may possibly be deferred; the sludge then being in a condition to permit any reasonable delays encountered during the disposal process.

A very important feature of the activated-sludge process is the unit quantity of sludge produced and the relation that this bears to the quantity of suspended matter carried in the crude sewage. A number of results bearing on this relationship have been obtained that show a loss in solids owing to the treatment, varying from 0 to 50%. At this time it is believed that a loss of 35% represents approximately actual conditions. The crude sewage carries 250 parts of suspended solids, which represents one ton of dry solids per 1,000,000 gal. of sewage flow. Assuming a loss in solids of 35%, there would be two-thirds of a ton of dry solids, 2 tons at 75% and 26 tons (30½ cu.yd.) at 97½% moisture. The sludge with a 75% moisture content weighs 59 lb. per cu.ft.

Since the tests were started a sample of sludge has been withdrawn from the settling tank regularly and analyzed. (See accompanying table.) The nitrogen content of the Cleveland activated sludge is less by 1% than that which other experimenters are securing with domestic sewage. Apparently an allowance must be made for longer aëration periods, as when stability or nitrification is desired and when packing-house wastes, even in small quantities, are present in the sewage. Fertilizer concerns designate the nitrogen value of a tankage by means of "units of ammonia," a term that is equivalent to about 1.2 times the total nitrogen figure in the table.

SUMMARY OF ANALYSES OF CLEVELAND ACTIVATED SLUDGE

	%	% Dry Basis						
	Moisture Content	Mineral Matter	Organic Matter	Nitrogen Total	Nitrogen Available	Phosphates (P_2O_5)	Potash	Fats
No. of Analyses.		20	20	19	13	18	3	19
Average...	97.5–98.0	51	49	3.21	1.65	1.73	0.29	6.77

The total nitrogen is determined in accordance with a modified Kjeldahl-Gunning-Arnold method (*Journal Industrial and Engineering Chemistry*, November, 1913), the available nitrogen by the alkaline-permanganate method, and the ether or fat soluble results are based on a 16-hr. period of extraction.

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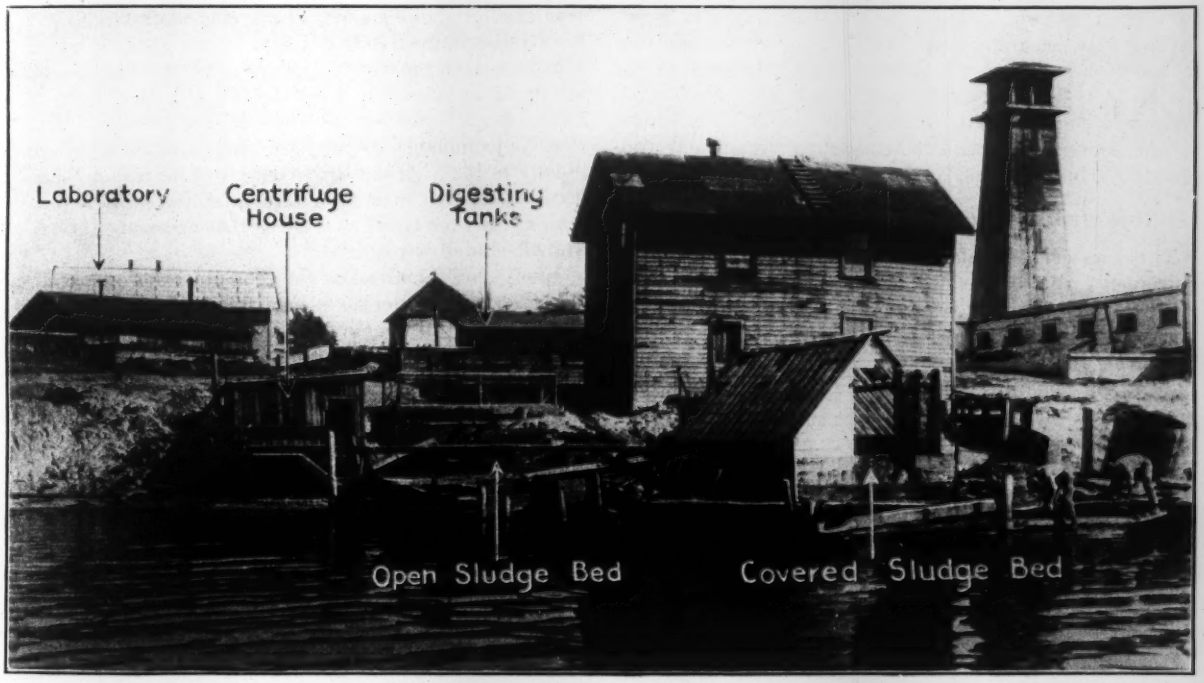
Continuous aëration of the sludge (97½% moisture) for a month reduced the fats 40% and the available nitrogen about 25%. The total nitrogen content remained constant, and if the period of aëration is reduced to five days, the original percentages obtain. Continued aëration has a tendency to reduce the quantity of sludge only slightly and sludge so aërated settles more rapidly.

Tank Concentration of Sludge

From the beginning of the tests the rapidity with which activated sludge settles has been an important feature of this process. Taking advantage of the same may offer a means of partially concentrating the sludge prior to reaëration or further dewatering. Tests so far conducted have been in tanks 5 ft. deep and in glass cylinders 9 and 15 in. in depth. A detention period of 4 hr. reduced the moisture content from 98 to 96% in the 9-in. glass cylinder, while a period of about 13 hr. was required to produce the same results in the 5-ft. From these results and others of a similar nature, it appears that the vertical velocity of subsidence from any given moisture content to another varies almost directly as the cube root of the depth of the tank. This indicates that a tank 20 ft. in depth will require a retention period of 36 hr. to produce the same moisture-reduction results. Before the tests are completed it is intended to try a tank of such a depth.

It is desired to emphasize the importance of the foregoing idea in designing concentration tanks, and that local conditions will determine just what expenditure is justifiable for this purpose. Also, the idea of tank concentration is important when looked at from an operation standpoint, there being quite a saving when handling 20 instead of 40 cu.yd. of sludge per 1,000,000 gal.

At one time during the tests it was thought that the prestige as regards an absence of odors that the activated-sludge process has enjoyed from the first would be lost on account of difficulties incident to the disposal of the sludge. Recently, however, there has been developed a means of producing a stable sludge, thereby eliminating any chance of objectionable odors during the disposal process. In carrying out the tests, sludge is removed by the air lift from the settling compartment to one of the tanks not in regular use and is there reaërated for a relatively long period. Present tests consist of determining the results produced by varying the time and air quantity elements and determining whether or not a slight change in the condition of the original settled sludge appreciably alters the result. At present from 20 to 25 cu.ft. of air per gallon of sludge treated appears sufficient when the aëration is continued for five days—that is, 5 cu.ft. of air per gallon per day. Sludge analyzed before and after the reaëration period, again when partially dried (75% moisture) and when dry has from a nitrogen standpoint the same manurial value. The reaërated sludge dries on sand beds a little faster than the ordinary activated sludge. In a partially dried condition it retains its chocolate color, is porous and smells like earth that has been covered for a long period with leaves. In reducing the moisture content over a steam bath from 75 to 10%, a slight but unobjectionable odor can be detected.



SLUDGE-DISPOSAL DEVICES AT CLEVELAND ACTIVATED-SLUDGE PLANT

So far no indications have developed that tend to make the success of this phase of the sludge problem doubtful. If such favorable results continue, an inexpensive means has been provided for eliminating any odors during the disposal of activated sludge. With current furnished at ¾c. per kw.-hr. the cost is estimated at 75c. per 1,000,000 gal. of sewage treated. Whether or not sludge can be reaërated more efficiently after tank concentration is a question.

In order to determine the possibility of digesting activated sludge, thereby eliminating any odors during the disposal process and reducing the volume of sludge to be handled, a tank 20 ft. deep was placed in operation April 24. At about 48-hr. intervals during the first month of

operation activated sludge was applied to the tank and allowed to decompose in the bottom, the clear and supernatent liquid being withdrawn at each filling. In a month a thick scum developed on the surface, and odors, such as accompany digestion or septic tanks, became noticeable. It was impossible to continue applying sludge as the tank filled up. After this filling the tank was covered to inclose the odors, allowed to stand and the digestion continued on an anaërobic basis. At monthly intervals, and sometimes oftener, sludge has been withdrawn from the bottom of the tank and analyzed.

The indications of digestion after five months are an increase in the odors, a reduction in the nitrogen content of from 2.74 to 2.27%, available nitrogen from 1.63 to 1.08, moisture content from 97.4 to 90.8%, but no reduction in the volatile matter. The sludge resembles partially digested sludge. In operating this tank an attempt has been made to digest activated sludge, first with the aid of a regular application of fresh sludge and then without. It is intended to continue the operation by mixing fresh sludge with partially digested sludge withdrawn from the tank; the mixture then to be allowed to digest further in a separate tank located next to the one now in operation. When the treatment and disposal of the sludge as a fertilizer ingredient is not warranted, it is desired to emphasize the practicability of this method of sludge disposal as applied to remodeling present-day two-story tank installations.

Dewatering Process a Matter of Drying

The dewatering problem is a drying proposition and for convenience can be divided into two steps: A primary, which involves reducing the moisture content to a point where the sludge may be readily handled—about 75% moisture—and a secondary step, which involves expelling most of the remaining moisture. The latter should only be necessary when the value of the sludge as a fertilizer ingredient warrants.

Since the first of May plain and reaërated sludge has been partially dried on sand beds covered with a greenhouse type of construction. Only in special cases has the process been carried beyond a reduction to a 75% moisture basis. Owing to weather conditions, such as the frequency of rains, the drying of either plain or reaërated sludge on open beds is greatly retarded. Any retardation is a detriment, as it permits decomposition to become active, which condition is a forerunner of unpleasant odors.

Drying Sludge on Sand Beds

The covered bed is 10x20 ft. in plan, divided into sections as required, and was the sand bed used during the year 1913 for drying Imhoff sludge. The filtering medium consists of 12 in. of fine lake sand with the exception that one division of the bed was of a graded material. Sludge on the graded bed dries no faster than on the plain bed; consequently, it appears that sand is capable of passing the water as fast as it enters. The additional cost for graded beds, therefore, does not seem justifiable. The solid material in the sludge settles so rapidly that within 4 hr. it is possible to siphon off at least 6 in. of the supernatent water from a 12-in. dose. It appears that it takes about a day longer for the sludge to dry down when the 6-in. layer of the supernatent liquid is not withdrawn. Consequently, the water is siphoned off practically all the doses. As a rule, within 24 hr. all the liquid disappears from the surface of the sludge. Within 48 hr. a great number of small cracks develop, breaking the sludge into nearly equal portions, which feature is somewhat different from the larger and fewer cracks that develop in drying Imhoff sludge. The moisture content at the end of four days is about 80% and decreases thereafter at the rate of 1% per day to a 75% basis. Generally, at the end of six days the sludge can be removed with a potato fork.

The high moisture content of the sludge materially increases its ability to penetrate into the sand. Imhoff sludge will retain sand equaling 40% of its weight, dry basis, while activated sludge retains about 60%. The graded bed is at a disadvantage in this respect, its retention being 75% when a 1-in. layer of sand is used on top. As a consequence, cheese cloth and sawdust have been successfully used for separating the sludge from the sand, about four applications being all that the cloth will survive. Doses 12 in. in depth seem to permit the largest yield per square foot of bed, although the data pertaining to this point are not conclusive.

At no time is there any odor during the drying of the reaërated or stable sludge. In drying plain sludge a thin brown film immediately develops on the surface, which to a large extent prevents all odors until the film is broken up in being removed. Beneath the film the entire mass turns black, and in rehandling the sludge offensive and objectionable odors are produced, owing principally to the high moisture content of activated sludge—a condition that makes the unit quantity so high that an area at least ten times as large as that necessary for drying Imhoff sludge is required.

Sludge has remained on the beds until thoroughly dried, but the period involved—three weeks—makes the use of sand beds impracticable for completely dewatering sludge.

Drying Sludge By Centrifuging

In order to concentrate activated sludge from about 98 or 95% moisture a centrifuge was installed. It was a rotary machine made by the Cleveland Laundry Machine Co. with a 26-in. basket, and was belt driven with a friction clutch provided for starting purposes. The basket was lined with a ¼-in. wire mesh inside of which was placed a canvas bag. The sludge was admitted through an orifice located directly over the center of the centrifuge. After a cake was formed, it was necessary to remove and clean the canvas bag for any succeeding runs.

About thirty runs under varying conditions were made. In general, the results permitted the passage of about 3 gal. of water per minute through the canvas, but a mat developed next to the canvas within 5 or 6 min. after starting. Continuing the operation without applying more sludge tended to compact the caked layer, free the water that was held within, and in about 30 min. the cake was of such a consistency as to stand up. In the best run, when the basket revolved about 1,200 r.p.m., 60 gal. of 97½% moisture sludge was admitted in about 25 min., and in 2 hr. the moisture content was reduced to 84%. Two additional hours reduced the moisture content further to 80%, the final product being a cake ¾-in. thick.

After the mat has formed there is a tendency, owing to wave action, for the basket to become unbalanced; and as a consequence six vertical vanes about 2 in. deep were fastened to the wire mesh and spaced equally around the basket. The vanes prevented the wave action, but there

was apparently no way to prevent a ⅛-in. layer of the mat next to the canvas from becoming dense. As soon as this happened, the water came to the inside surface of the cake and remained there. This fact suggests the possibility of a solid bowl type of centrifuge, in which the clear water can be removed without passing through the caked layer. In order to increase the porosity of the matted formation, garbage tankage was mixed with the sludge; but the results were not improved.

The results indicate that activated sludge might possibly be concentrated by centrifuging to approximately an 85% moisture basis. The trouble experienced is the same that is encountered in the use of presses either of the vacuum or pressure type. Increasing by more pressure the density of the formed mat simply limits the capacity of the apparatus prior to its efficient output. Consequently, if it is satisfactory for the process to be intermittent, some means must be provided for automatically removing the clear water, while continuous operation involves the removal of the mat or both the clear water and the mat. The results secured with the present machine, while not encouraging, lead the writers to believe that more favorable and satisfactory results can be secured with a centrifuge designed in accordance with the suggestions already made.

Centrifuges as built at present sometimes require screening the material prior to centrifuging and reduce the moisture content to only an 85% basis. Sludge so reduced could then be applied to sand beds. Points in favor of centrifuges are their capacity per unit of area required and low initial cost. A machine about 2 ft. in diameter, which has been simplified by its use in other fields and which is capable of handling the sludge from 2,000,000 gal. of sewage per 24 hr., should appeal to experimenters interested in the solution of the sludge-disposal problem.

During the tests in 1913 a Sweetland press was installed and used for pressing Imhoff sludge. The conclusion reached was that a press 15 ft. long with leaves 3 ft. in diameter, spaced 4 in. c. to c., will produce five tons of caked sludge—70% moisture—when operating 21 hr. each day. These results were produced with sludge containing 85% moisture, and it is believed they can not be equaled with sludge whose moisture content is from 98 to 95%. When operating three 8-hr. shifts (basing the capacity of a press upon the amount of cake produced) there is required a press for every 3,000,000 gal. of sewage treated. If, however, the number of presses is based upon the volume of wet sludge handled, one press is capable of dealing with the sludge from only 500,000 gal. of sewage.

Just how much sludge a press can handle efficiently is an open question. For a large installation a comparison must be made between a layout consisting of a small number of large presses and one with a large number of small presses. From the standpoint of efficiently using the labor, a large number of small presses seems preferable, but this may not be so pronounced with an hydraulically operated installation. In the year 1913 an actual bid price for the above-mentioned press installed was $4,500, which represents an expenditure of $1,500 per 1,000,000 gal. of sewage to be treated. An estimate of the cost of pressing activated sludge can probably best be made by comparison with sludge presses in use at chemical precipitation plants allowing for recent improvements in press design.

The drying of activated sludge to a 10% moisture basis would only obtain when the value of the sludge as a fertilizer ingredient warranted. During the present tests three attempts have been made with steam and direct-heat driers to reduce the moisture content of sludge from about 75 to 10%—a marketable condition. Also, some difficulty has been experienced in accumulating a quantity sufficient to get a normal run with a direct-heat drier. One run was attempted at the Cleveland garbage reduction works, but the quantity used—1,200 lb., 80% moisture—was not sufficient; it being impossible, owing to the small amount discharged from the drier, to judge the results of the test.

Results in drying Imhoff sludge at Cleveland and in an eastern city, in direct-heat driers, require 2½ tons of 40% moisture sludge to produce one ton of the dried material. In passing the sludge through the drier a large amount is burnt up or lost in the dustroom. Similar conditions are anticipated in drying activated sludge. The estimated cost of this method of drying is $3 per ton of dried material when using gas, which is cheaper than coal and which also permits a control of the flame length. It may be possible to secure a lower cost by staging the process—that is, first passing the sludge through a direct-heat dryer as a preliminary process and then through a steam-jacketed drier. High temperatures produce more efficient results with substances having moisture contents between 75 and 45%, and low temperatures act likewise between 45 and 10%.

Two tests have been conducted at the works of a local fertilizer company for drying reaërated sludge in a steam drier, which was a "Buckeye" of the steam-jacketed type, 6 ft. in diameter with paddle agitators. At the end of the first hour the material was in a "mushy" condition. About 1,200 lb. of sludge alone with a 75% moisture content was first tried, and after 2½ hr. of agitation, which is about twice the period of a usually successful run, the materials balled up. The balls were about the size of one's fist, caked hard on the outside, and the portion so formed represented about one-half of the final residue while the remainder resembled pea gravel. The operation was continued for 3½ hr., when the moisture content of a pulverized ball was 37% and of the pea gravel 21%. Although too much weight should not be given the results obtained from this one test, they tend to show that sludge alone cannot be economically dried in a steam drier to a 10% moisture basis. It is believed however that excessive balling up can be prevented. The nitrogen value of the sludge remained the same, and no odors were present.

No trouble at all was experienced in drying the sludge when mixed half and half with tankage. About 500 lb. of each material was used, the tankage having a moisture content of 45%. A run of 2½ hr. reduced the moisture content of the final product to less than 1%. When mixing the two products, the nitrogen value is reduced, tankage averaging about 2.75% ammonia; but the low amount of grease in tankage (3%) reduces the average for the mixed material.

Final Disposition of Activated Sludge

The final disposition of activated sludge has been given considerable thought and study. Its disposal as a fill on low ground naturally suggests itself, but our increasing standards as regards unsightly conditions, odors and nuisances demand that the material be disposed of without offense. Plain activated sludge with 75% moisture can-

not, practically speaking, be transported to dumping grounds or storage sites where the sludge is accessible for agricultural purposes. Sludge of this character deposited on low lands subjected to rain, snow or floods will take up moisture and, owing to active decomposition, rapidly become offensive. Sludge in storage bins or trenches when covered over with a crust and apparently satisfactory but water-soaked may, when carted away and spread upon the ground, give the nearby treatment plant an undeserved black eye as regards odors.

Just what moisture content a sludge may have, and in what condition it must be in order to be satisfactorily used as a fill, is a question. Reaërated sludge with about 75% moisture has remained for two months in a box which was opened to the weather, and when removed no objectionable or unpleasant odors were noticed, while plain activated sludge when put to a similar test produced rank odors.

Activated Sludge as a Fertilizer Ingredient

A revenue from sewage sludge to offset the cost of operation of a treatment plant is of particular import at this time when our municipalities are in such financial straits. Consequently, a method of treatment that produces a sludge with a higher manurial value than any yet known method provides possibilities of fulfilling the above-named conditions. Apparently the activated-sludge process produces a sludge with a manurial value at least twice that found in any other sludge, but the ratio of solid matter to water from a dewatering standpoint complicates the reduction of the material to a marketable condition. An efficient solution of the secondary step of the dewatering process appears practical, but as much can not be said of the primary or concentration stage.

There does not appear any good reason to expect to use dried sludge other than as a fertilizer ingredient. The available nitrogen, which averages about 50% by the alkaline-permanganate method, classes the material as low grade. An accurate analysis can be considered a fair guide to the value of the product and probably more reliable than any field tests of less than five or ten years' duration. A price no better than 10c. per lb. is about all that can be expected for the ammonia and ½c. per lb. for the bone phosphates ($Ca3P_2O_8$). The amount of potash is negligible. There would then be, according to the average analysis, a gross return of about $8.20 per ton, dry basis, or for Cleveland conditions $5.50 per 1,000,000 gal. of sewage. A commercial demand for ammonia such as this country is now experiencing, and which it is prophesied will continue, may change conditions somewhat.

Summary and Conclusions

At Cleveland the solution of the sludge-disposal problem remains the important issue of the activated-sludge process of sewage treatment.

Unless the unit quantities of sludge produced are materially lessened, the use of sand beds for dewatering activated sludge is financially prohibitive.

Available data indicate that presses are apparently the best known method for effecting the primary stage of the dewatering process, irrespective of whether or not the sludge as a fertilizer ingredient warrants further drying.

Present data are not sufficient for estimating within narrow limits the cost of sludge disposal.

A revenue from activated sludge involves a large initial expenditure, coöperation with private interests, a commercial demand and the strongest assurance that any agreements will be faithfully observed for a long term of years.

Sludge to be disposed of as a fill must be, practically speaking, in a stable or nonputrescible condition.

Future tests in the main should be directed toward this phase of the activated-sludge problem. Of particular import are studies pertaining to centrifuging, tank concentration and the digestion of the sludge—the latter for providing a means of eliminating odors and reducing the unit quantities to be disposed of.

The writers have taken a great deal of pleasure in showing the activated-sludge installation to visitors during the past summer, and they desire to express their appreciation for the suggestions made during these visits. Robert Hoffman is chief engineer and commissioner of the Division of Engineering and Construction and is in charge of all sewerage and sewage-disposal improvements. The work herein described is under the supervision of the writers, with A. G. Husted, assistant engineer, in immediate charge.

Seatless Rapid-Transit Cars

To increase the carrying capacity of the rapid-transit railways in London, England, during the hours of peak load or congested traffic, the introduction of cars without seats has been proposed. It is considered impracticable to increase the length of trains and stations, or to increase the number of trains. According to *The Engineer* (London) the cars of the District Ry. have seating accommodation for about 48 passengers, while in a crowded train there may be almost as many standing, to their own and the sitters' inconvenience. Every person seated occupies approximately 6 sq.ft. of floor space, whereas he may stand comfortably in half that area. Hence, the removal of all seats from a car would add at once one-third to its capacity. But as the whole space could be used more efficiently the number of passengers would be nearly doubled with no more personal inconvenience than at present.

The Engineer says: "We do not think the traveling public would object to such cars if they were neatly designed. No one can now count with certainty on finding a seat, most of the journeys are short, and strap-hanging is a familiar exercise against which no one now thinks of protesting. Passengers as far as possible would stand round the sides, leaning against the walls, hence the windows would have to be reduced in size, and would be partly blocked by packed humanity. This is a comparatively unimportant matter, since artificial lighting is already the rule, but in any case might be met by roof lights made with any of the new unbreakable glasses. A padded rail would be provided to lean against, and if small arms were added they would make it easier to stand gracefully against the buffets and shocks of starting and stopping. From the roof would hang a forest of straps, and down the center, posts with long vertical rails might be arranged. The floor should be covered with a grid of some kind that would help to keep it dry in wet weather. More doors, of course, would be provided than at present, and the vestibules at the ends would be got rid of."

Completing the Municipal Bridge at St. Louis, Mo.

SYNOPSIS—The last link in this bridge over the Mississippi is the 3-mi. approach viaduct at the east end. Its design and construction are described. The work was done by city forces.

The great double-deck municipal bridge built across the Mississippi River by the City of St. Louis will soon cease to be an isolated and unavailable structure. The long viaduct on the east (Illinois) side of the river is nearing completion and will provide the necessary connection with the bridge proper. The highway portion of this approach will soon be ready for traffic. The accompanying illustrations show the work in progress. Figs. 1 and 2 show the erection of truss and girder spans respectively. Fig. 3 shows the placing of the last girder to close the gap, on Sept. 22, 1916.

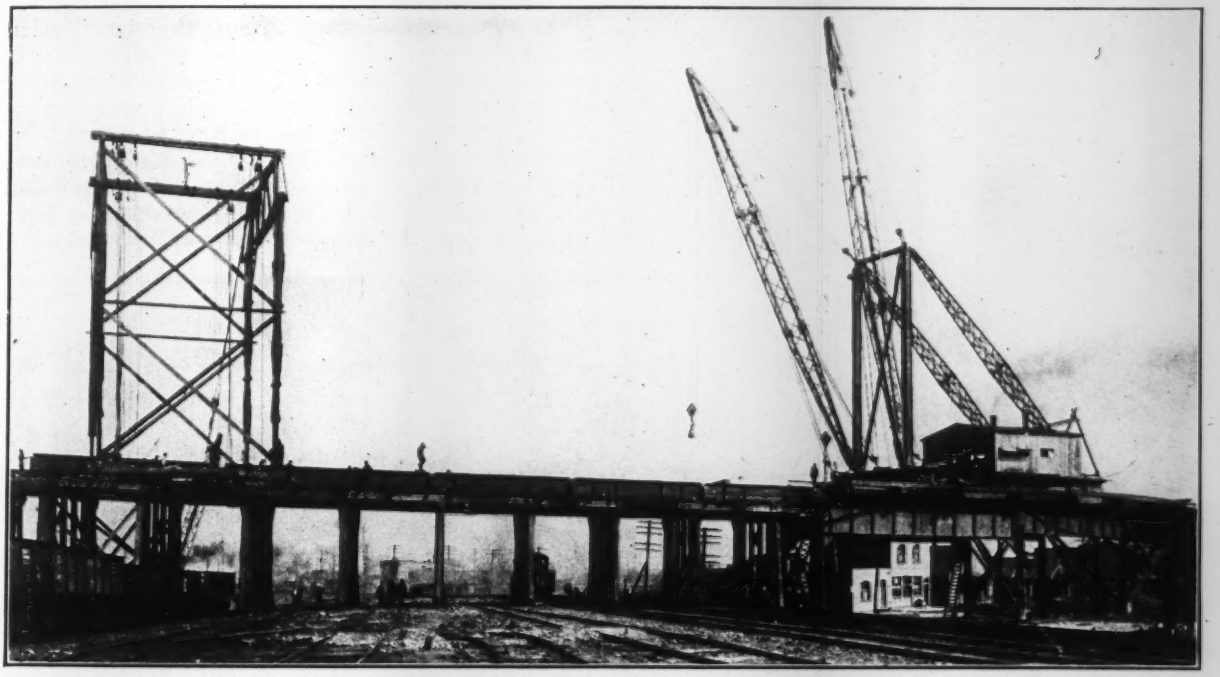


FIG. 1. ERECTING ONE OF THE TRUSS SPANS ON THE EAST (ILLINOIS) APPROACH TO THE MUNICIPAL BRIDGE OVER THE MISSISSIPPI RIVER AT ST. LOUIS, MO.
This shows the gantry traveler and one of the big steel derrick cars

The three 668-ft. river spans of this notable bridge were completed in 1912. Controversy developed as to the location of the west (St. Louis) approach, but after some delay this was settled and the approach was completed in 1914. The building of the east approach, however, required an additional issue of bonds. This was twice voted down, but finally the city secured the labor vote by agreeing that the work should be done by city forces (instead of by contract) and that only union labor should be employed. At the third election, in 1914, the bond issue of $2,750,000 was approved. Work was commenced early in 1915, but was delayed and hindered by several strikes and labor controversies.

The work is under the direction of the Board of Public Service, a special department being organized for this purpose, as described in *Engineering News*, Sept. 23, 1915. Clinton H. Fisk, Chief Engineer of Construction, is at the head of this organization; W. F. Collar is Superintendent of Construction. The working force approximates about 300 men, for steel erection, concreting, etc.

Description of Bridge Approaches

The bridge is a double-deck structure, with the railway tracks on the lower deck. Beyond its east end, the upper (roadway) deck swings to the north and runs parallel with, but still above, the railway for about 2,300 ft. It then turns to the northeast (see Fig. 2), and extends for 3,000 ft. before coming down to street grade in the outskirts of East St. Louis, Ill. It ends with a fill about 540 ft. long, having concrete walls and parapets. The maximum grade is 4.15%. The railway-viaduct approach continues in a direct line east from the end of the bridge and has a total length of about 13,000 ft. before coming to the ground level. Its maximum grade is 0.98%. The railway approach ends in an earth-fill 600 ft. long, this being followed by 1,800 ft. of earth-fill between retaining walls.

A footway (approached by stairs at the shore piers) has been maintained across the lower deck of the bridge for some time. The roadway approach, now nearly completed, will enable the bridge to be opened for street traffic. The railway approach will be finished a little later, but no arrangements have been made as yet with

the railways that are expected to use the bridge. The car tracks on the roadways will be available only for east-side electric lines, the St. Louis street railway system having a gage of 4 ft. 10 in., so that no connection is possible. For the same reason the St. Louis street railway does not use the Eads bridge, which is crossed by the East St. Louis car lines and some interurban lines running to a terminal at the St. Louis end of the bridge.

The new east approach is mainly a plate-girder viaduct with spans of 60 to 75 ft., as described in *Engineering News*, Sept. 2, 1915. It has four through truss spans. Two of these are spans of 184½ ft. and 227¼ ft. on the railway portion, and one is a 263¼-ft. span on the roadway portion. All these cross the Illinois Central R.R. The fourth is a three-truss span of 296 ft., carrying the railway and roadway at the same level and crossing the Mobile & Ohio Ry. and the Southern Ry. The railway viaduct is designed for a live-load of 5,000 lb. per lin.ft. of track, and the roadway viaduct for a live-load of 100 lb. per sq.ft.

The ground is low, but it will be filled in later as the city (East St. Louis) grows; the pedestals for the viaduct columns are therefore carried up to the future street grade. The foundations are groups of concrete piles driven to a depth of about 25 ft. The piles are of circular section about 15 in. in diameter, with deep vertical corrugations giving increased surface area, which adds considerably to the skin friction. A steam pile hammer was used, and a water jet assisted the work. The manufacture and driving of these piles were done by Charles N. Lund, of St. Louis, and formed the only part of the work done by contract.

Construction of Pedestals

The steel columns are carried on tapering pedestals, 4 to 6 ft. square on top, with sides having an inclination or batter of 1½ in 12. Each stands on a 12-ft. octagonal footing block about 3 ft. thick, which incloses the heads of the group of piles. The soil is filled ground for a depth of about 10 ft. on top of sandy clay. Fig. 4 shows some of the viaduct pedestals, with one of the piers for a truss span at the left. It shows also one of the long-boom locomotive cranes used on the work.

Concrete pier foundations sunk to rock were required in some cases, partly to carry the heavy loads of the truss spans and partly on account of unsatisfactory soil conditions. There are 16 of these piers, 12 of which were sunk by the pneumatic process to a depth of 45 ft. The other four were built as open wells.

Most of the pedestals were built in sectional steel forms [illegible] by the Blaw Steel Construction Co. These forms were adapted to various sizes by means of special corner pieces attached at two diagonally opposite corners. Wood forms were used for some of the largest pedestals, which were too large for the steel forms in hand and too few in number to warrant purchasing special steel forms. Owing to their height and tapered shape, the wet concrete exerted an appreciable upward pressure or lift upon the forms, and ¾-in. anchor bolts were built into the footings for the attachment of the forms. In one or two cases the forms shifted and had to be secured promptly, and in at least one case a steel form rose bodily and then overturned.

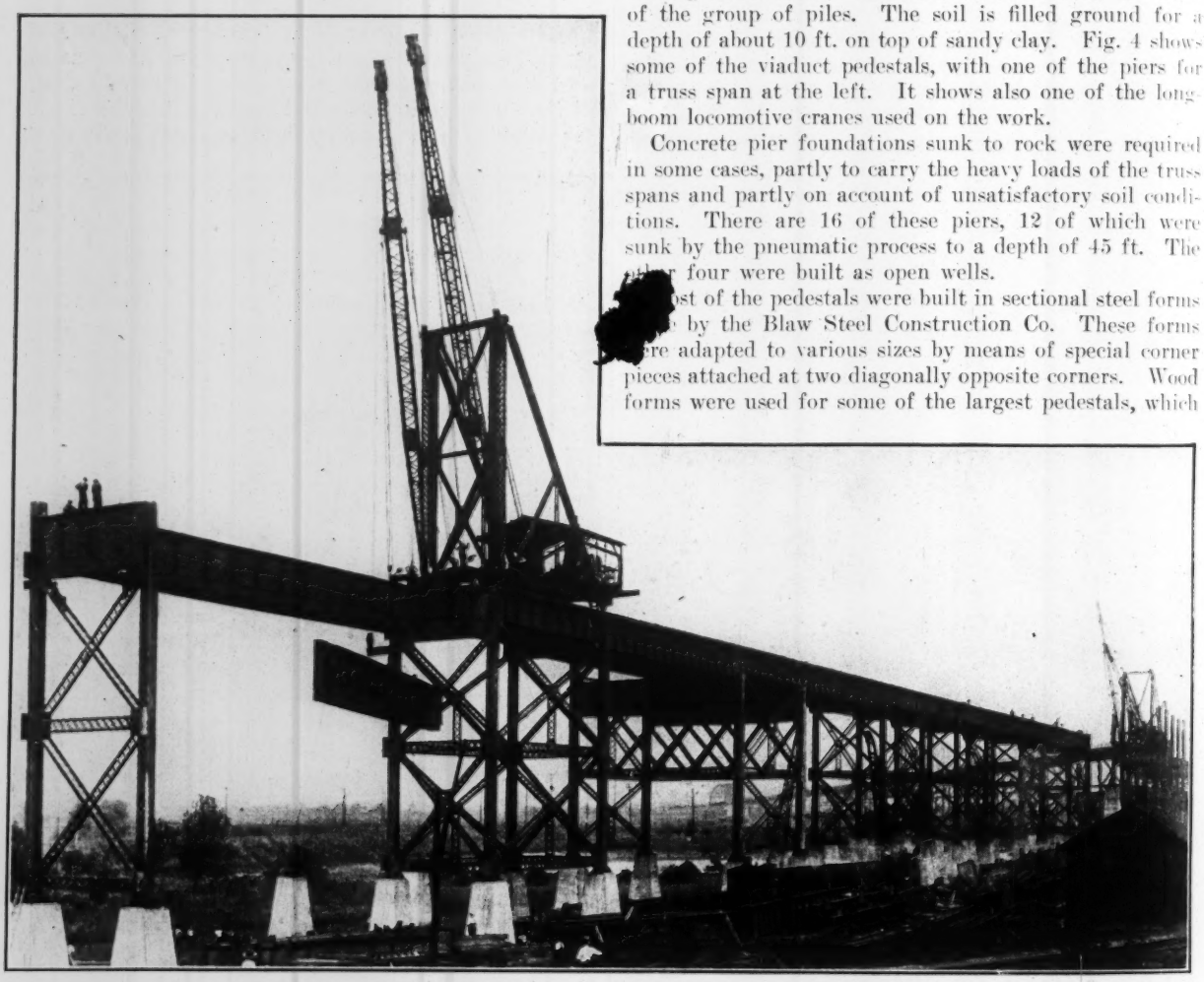


FIG. 2. STEEL DERRICKS ERECTING THE VIADUCT APPROACH

The derrick at the left is working on the combined railway and highway approach (having three-post bents). Note that both booms are carrying the girder. The derrick at the right is standing where the highway approach diverges (to the left), the railway approach continuing on a straight line

The concreting of the pedestals was done with a portable plant consisting of a car carrying the mixer and bins. The concrete was placed with drop-bottom buckets handled by a derrick car. One of the truss spans is at a height of about 50 ft. and is carried at each end by a pier having an arched opening in the central portion to reduce the weight. The concrete for this was placed by an A-frame derrick handling the drop-bottom bucket with a long boom.

For the truss spans, very heavy falsework was used, in some cases having double bents (braced together) placed between the tracks. On these were pairs of the floor stringers (for the viaduct span) used as transverse caps.

Details of Floor System

Owing to increase in wheel loads since the structure was first designed, it has been necessary to strengthen the railway floor system. This floor will have an open deck of ordinary construction, with rails laid on wood ties resting upon the stringers.

The roadway floor construction consists of a concrete slab resting on longitudinal joists and girders 4½ to 5 ft. apart. The concrete is extended downward to inclose the joists. This slab carries the wood-block paving. The car tracks are laid at the sides of the roadway and have 90-lb. T-rails of the Am. Soc. C. E. section. These are carried by chairs 33 in. apart on the outside girders and the 15-in. I-beam joists. These chairs have insulating strips and top clips that fit over the rail base. On the fill at the end of the roadway approach the car tracks are laid with Carnegie steel ties embedded in the concrete base for the paving.

FIG. 3. PLACING THE LAST GIRDER TO CLOSE THE GAP: SEPT. 22, 1916

Note the way in which the girder is held by clamps on a swing beam carried by two hoisting lines and booms

FIG. 4. PEDESTALS FOR VIADUCT BANK AND PIER FOR TRUSS SPAN

For erecting the steel viaducts two travelers were used both running on the structure, as shown in Figs. 1 and 2. They were of steel construction, with platforms 24x65 ft., mounted on wheels on a track of 19½-ft. gage. Outrigger beams on each side of the platform provided a wide base for stability in making side lifts. Each had two masts 50 ft. high and two booms; the length of the booms was 100 ft. on one machine and 95 ft. on the other, with a 30-ft. removable section in the middle. For each boom there was a two-cylinder 10x12-in. engine with two drums and four winch heads operated through clutches. Two of the winches were for the guy lines used in swinging the booms laterally.

For handling long and heavy pieces both hoisting lines are attached to a swing beam or equalizer from which the load is suspended. This arrangement is shown in Figs. 2 and 3. The heaviest pieces handled were 38-ton girders and 35-ton top-chord sections for the middle truss of the three-truss bridge.

The traveler with 100-ft. booms could handle 30 tons at 60-ft. reach with each boom. The one with 95-ft. booms could handle 28 tons at 50-ft. reach. There were also three locomotive cranes, two with 60-ft. booms for 30-ton loads and one with a 75-ft. boom for 60-ton loads. A gantry traveler of timber construction, shown at the left in Fig. 1, was used in erecting the two-truss spans.

The Municipal Electric-Lighting Plant of Melbourne, Australia, was established by the City Council in 1894. The city has invested about $5,000,000 in the plant, and its net earnings above operating expenses in 1915 were $500,000. After paying interest and sinking-fund charges and deducting depreciation and reserves, the plant made a net profit in that year of over $200,000. The base charge for current is 7c. per kw.-hr., which is the lowest in Australasia. The government of Victoria is now proposing to take over this municipal plant and operate it in connection with the city street-railway lines. This change, however, is opposed by the city authorities, who claim that since the city has established and built up a profitable electric business, it should continue to own and control it.

New Railway in Indiana for the Pennsylvania System

SYNOPSIS—This 41-mi. line is an important link for a high-speed train service, and its construction includes a number of interesting features. The construction work and the types of bridges are described.

The new railway between Indianapolis and Frankfort, Ind., now being built by the Vandalia R.R. (under the name of the Indianapolis & Frankfort R.R.) will give the Pennsylvania System a direct line of its own between Chicago and Indianapolis. Although only 41 mi. in length, it will be an important link. At present the Pennsylvania has a route from Chicago over its own line (the Panhandle) to Kokomo, Ind., and thence by trackage rights over the Lake Erie & Western Ry. to Indianapolis, beyond which it has its own lines again to Cincinnati and Louisville. The new route will be over the Panhandle to Logansport, the Vandalia to Frankfort, and then the new line into Indianapolis. The distance will be about the same, but the traffic facilities will be much improved. The cost will be about $4,000,000.

The line runs approximately north from Indianapolis, and connects two east-and-west lines of the Vandalia R.R. It has an ascending grade for a few miles from each end, and then crosses flat country. The maximum grades are 0.3% northbound and 0.5% southbound. There are few curves, and the sharpest of these are only 1°, except for the junctions at either end, where trains run at reduced speed.

The line begins at Ben Davis, six miles west of Indianapolis, on the St. Louis division of the Vandalia R.R. It runs north to Lebanon (27 mi.), where it is elevated but keeps on the outskirts of the town. Thence it continues to Frankfort (14 mi.), connecting with the Michigan division of the Vandalia R.R. at a little distance west of the town. Here there will be a general revision of tracks. There are no other towns of importance, and only a few local stations will be built.

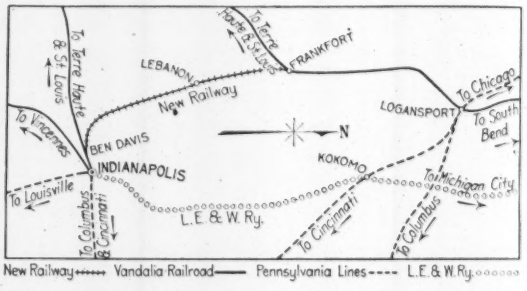
This new line was proposed and surveyed about four years ago, and surveys were again made in 1914, but definite action was not taken until 1916. Construction was commenced in May, and it is expected that the line will be put in operation next summer.

Being intended for heavy and high-speed traffic, all grade crossings of railways (steam and electrical) and highways are avoided. There are also 24 under-grade and two overhead crossings of highways. This necessitates a large amount of bridge work. The country is mainly flat, with some rolling ground, and the line is mainly on fill in order to cross above roads and railways. The cuts and fills are being made for single-track at present, in order to complete the connection as soon as possible; but all structures are built for double track. The heaviest fill is on the six miles at the south end of the line, and the construction of this was described in *Engineering News*, Oct. 26, 1916.

The earthwork (for single track) includes about 2,700,000 cu.yd. of fill, 230,000 yd. of cut (exclusive of borrow-pits) and 60,000 yd. of masonry for 47 bridges (double track). There will be 33 concrete bridges and 14 steel bridges, only three of the latter having truss spans.

There are five borrow-pits and all the excavation is done by five Bucyrus steam shovels. Most of the filling is done from temporary trestles, using standard-gage 12-yd. dump cars (averaging 10-yd. loads). Narrow-gage equipment, with 4-yd. dump cars, is used for a borrow-pit serving some of the lighter work near the northern end of the line. The temporary trestles have bents of four posts (two batter posts) and two diagonals, all round timbers with square cap and sill. Longitudinal bracing is placed between bents at intervals.

The width of roadway at subgrade is 24 ft. for the present single track, to be widened to 36 ft. for double track, with tracks spaced 13 ft. c. to c. In some places



MAP SHOWING NEW FRANKFORT & INDIANAPOLIS R.R. AND ITS RELATION TO THE PENNSYLVANIA SYSTEM

three tracks are to be provided, the third being a relief track for freight traffic, and near Frankfort there will be a four-track section. The tracks will be laid with 100-lb. rails and white-oak ties, with 24 in. of gravel ballast under the ties. The slopes of the fills are 1 on 1½, and probably these will be sown with clover. The right-of-way averages 100 ft. in width, and is inclosed with woven-wire fencing on galvanized steel posts of circular section. Lugs stamped out of the steel serve to hold the fence wires. This fence is topped with a single strand of the very heavy barbed wire designed for use in entanglements on the European battlefields.

At the crossing of the Cincinnati, Indianapolis & Western Ry., near Indianapolis, the grade of this line was lowered (to a maximum of 5 ft.) for a distance of about 4,000 ft., in order to avoid undue height of fill. This was done at the expense of the Vandalia R.R., and was the more easily arranged since it improves the grade of the older line.

Bridge Design and Construction

Three interesting features in regard to the bridges are the number and variety of these structures, the use of concrete arches for the standard highway crossings, and the attention given to the effective appearance or ornamentation of the bridges.

The concrete is made with washed and graded gravel, but as the fine and coarse materials tend to segregate

during shipment, a stock of sand is kept on hand in case the gravel as delivered should be found to have too small a proportion of fine aggregate. In some cases gravel is used for concrete in the lower portions and stone for that in the upper portions. The mix is 1:2:4 for reinforced work and 1:3:6 for footings. About 10% (by weight) of hydrate of lime is added to the cement in order to make the concrete dense and waterproof, and to make it flow readily around the reinforcing bars without being made too wet or sloppy. The arches and flat-top spans are waterproofed with Barrett, Minwax and Lewis compositions. Over this is 2 in. of concrete, with expansion joints. The backs of abutments and wing walls are given a single coat of tar.

For exposed surfaces, the only treatment during construction is to spade the coarse material away from the face of the form. After removal of the forms, these exposed surfaces are rubbed down with a cement brick and water and painted with a thin cement grout. This gives a smooth surface of uniform color. The rubbing brick is made of a 1:3 mix of cement and sand.

An effective appearance of the concrete and spans is obtained with very simple treatment. The spandrels have panels outlined with V-grooves, all edges are chamfered, and the copings of bridge and wing walls are unusually deep and massive. At the crown, beneath the coping, is the date (1916), and an unusual feature is that the figures are raised instead of being sunk in the concrete, as is the usual practice. This requires special care in the removal of the form. On some of these structures the raised figures are reinforced by ¼-in. horizontal rods, which are wired to the main reinforcing rods and project slightly into the figures.

As a rule, the arches are built for full width in one operation. In some cases, where the supply of material was insufficient for this, they were built in parallel sections or ribs, with no bonding between them.

The standard highway bridge has an arch of 40 ft. span and 8 ft. rise, with a clearance of 16 ft. at the center and a width of 32 ft. between curbs or parapet walls. The arch is a true ellipse. For the crossing of the old National Road (near Indianapolis) a 50-ft. arch span is used, with ornamental parapet walls which are cast in place. The Sugar Creek bridge has three 65-ft. elliptical arches. Instead of a parapet wall there are concrete posts carrying a railing of two lines of pipe.

Flat Slabs Also Used

Flat-slab spans of I-beams and concrete are used where headway conditions do not permit of arches. An interesting structure of the flat-deck type is a two-span bridge near Indianapolis which has a 35-ft. span over the Rockville road and a 27-ft. span over the Danville interurban line of the Terre Haute, Indianapolis & Eastern Ry., which runs alongside the road. The outside girders have curved ends resting on the abutments and center pier. Rectangular boxes of reinforced concrete are used for large culverts and for private farm openings or cattle passes. These range up to 18x10 ft. For smaller openings, 24 to 48 in. cast-iron pipe is used. This is either ordinary pipe or special culvert pipe of the lock-joint type, in 6-ft. lengths. At drainage ditches 30-ft. deck-girder spans on concrete abutments are used, so that these can be removed by a derrick car to permit the passage of dredge boats (as required by law). [illegible]

some of the steam and electric railway crossings, there are steel truss spans of about 124 to 180 ft. There is only one girder span, 81 ft. long. The bridges over steam railways require high abutments, as a clearance of 22 ft. is required by law.

Another interesting structure will be a highway bridge over the four-track line near Frankfort. This will have a central plate-girder span with wood floor, supported on concrete bents, while the side spans (over the slopes of the cut) will be of concrete slab and beam construction.

The formation is mainly stiff clay, with some gravel, but in some places the clay is very soft. For bridge foundations 20-ft. timber piles are used, driven 14 to 18 ft.; but 40-ft. piles are required where the ground is soft. The spacing is generally 36 in. c. to c., or 33 in. in soft soil.

For delivery of materials, spur tracks are laid from the several railways crossed, and carried along the right-of-way.

Construction Methods

In view of the large number of bridges and the necessity for pushing this work rapidly, the contractors installed several concreting plants, but (as noted above) scarcity of labor prevented all of these being operated simultaneously. Most of these were fixed plants with 1-yd. drum mixers, and timber elevator towers with booms and spouting of the Insley design. The booms were mainly of timber, so built that the main spout from the tower passed through the boom and had its outer end suspended from the end of the latter. In this way the boom and spout were raised and lowered as a unit.

At Lebanon there are several bridges (of various types) within a short distance, and for this work a portable concreting plant was rigged. It consisted of a flat car, with elevator tower at one end, 50 ft. high above the car floor, with the guides or leads extending nearly to the ground, so that the bucket could drop beneath the floor level to receive concrete directly from the ¾-yd. Lakewood mixer at this end of the car. Behind the mixer was a 24-yd. storage bin, with floor sloping forward, so that the material was chuted to the charging hopper of the mixer when lowered to rest on the floor of the car. Behind the bin and at the rear end of the car was a hoisting engine and vertical boiler, and also a separate boiler for the mixer engine. The concrete material was handled from cars or stockpile to the bin by means of a locomotive crane with grab bucket. This machine was used also to unload coal, and to do the excavating for the bridge foundations at this point.

In the arch falsework the lagging is carried on three-segment plank ribs supported on three lines of square posts connected by transverse diagonal bracing. Three sills (at right angles to the tracks) are laid on the unexcavated core between the sidewalks, and on these are round posts about 4 ft. high supporting heavy longitudinal caps of square timber. The posts of the centering are carried by these caps, each post resting on a pair of wedges which provide for adjustment and for releasing the centering after the arch concrete has set. The concrete is left usually for 28 days before this is done. The plank ribs of the centering are spaced 30 in. c. to c.

The contract for the entire construction was let to the Dunn & McCarthy Co., of Chicago, which is doing all the work with its own forces (without subletting).

Labor has been hard to get and hard to keep, and progress has been delayed in this way. To expedite the work numerous concreting plants were installed, but several of these were idle at times owing to lack of men. There are seven camps on the work. The contractor has a superintendent on each residency and a general superintendent for the entire work. The railway company furnishes rails for the temporary tracks, and also the cement, reinforcing bars and hydrate of lime. The contractors furnish gravel, form material, ties, spikes and track bolts, and use their own excavators, dump cars, locomotives and concreting plants.

The line is divided into four residencies, with Resident Engineers as follows: A. F. Dye, 6 mi. (at Indianapolis end); H. L. Hodges, 10 mi.; W. N. Nickerson, 11 mi.; Will Duncan, 14 mi. H. T. Whitney is Engineer in Charge, and W. R. Britton is Assistant Engineer in Charge.

In connection with this new line improvements will be made on the present line of the Vandalia R.R. from Logansport to Frankfort, 37 mi. Grades will be reduced to a maximum of 0.3% southbound and 0.5% northbound. It is being double-tracked at each end, and this work will be extended over the entire distance within two years. There will be also a rearrangement of terminals at Logansport to improve the connection with the new line.

This work is being done by Culbertson & Son, of Cleveland, Ohio, who are using two steam shovels with 2½-yd. buckets, and trains of 12-yd. dump cars. The work-train locomotives are rented from the railway. In widening on grade reduction a single-track cut at the new grade is cut through, and track laid in it. Then the old track is torn up, and the steam shovel widens the cut for the second track. At road crossings, the fill is leveled and spread by slip scrapers. This improvement work is under the direction of H. C. Johnson, Division Engineer.

The construction of the new line and the improvement of the present line are under the direction of F. T. Hatch, Chief Engineer, and Maurice Coburn, Principal Assistant Engineer, of the Vandalia R.R. The bridges were designed by J. E. Starbuck, Bridge Engineer of this railway.

Lighting Freight Yards

The lighting of freight yards is an important matter in railway service, not only to increase the rapidity and efficiency of operation of the yards, but also to reduce the damage to freight and equipment. In a report presented at the recent annual meeting of the Association of Railway Electrical Engineers it was shown that the lights may be supported either by towers, poles or catenary construction. Towers may be built to any desired height, and the cost per foot of height decreases as the height increases. As a rule this system is not economical, on account of the high cost and the possibility of future changes or removal of the yards, which would make the towers useless. Catenary construction is excellent in allowing proper location of units, but is expensive and subject to rapid deterioration.

For wide spacing of units, towers or poles are the most economical—poles being preferable in the majority of cases. For close spacing of units, catenary construction is the cheapest and most satisfactory. The usual space between poles for distribution lines is about 100 ft., and the most economical installation will use these poles for supporting the lighting units. This would allow lights to be placed either 100 ft. or 200 ft. apart and approximately 35 ft. high (35 ft. being the most practical mounting height on wood poles).

Yard lighting is of most importance in relation to classification yards, and a typical arrangement of units for such a yard (operated by gravity switching) is shown in Fig. 1. The lights on the approach to the summit, or hump, should be spaced as shown in Fig. 2, being placed on that side of the track from which the car cutters operate, and at a distance from the track equal to one-third their height. The lamp should be covered by a reflector to screen the light from the trainmen's eyes and prevent its interference with signals. On the ladder tracks the

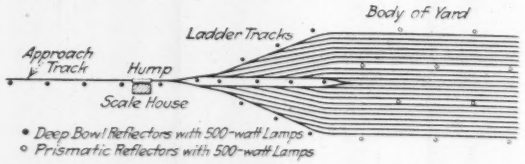


FIG. 1. PLAN OF TYPICAL ARRANGEMENT OF LIGHTS FOR CLASSIFICATION YARD

spacing should not exceed that given in Fig. 2 (75% of this distance is preferable); the lights should be placed as close to the switches as possible, and every switch should have a light within 40 ft. In the body of the yard the lights in each row should be spaced as in Fig. 2, and the spacing of the rows should not exceed the distance there given (75% of the distance being preferable). The lights in adjacent rows should be staggered.

In repair yards the endeavor should be to have each car evenly lighted on the roof and sides, and as much light

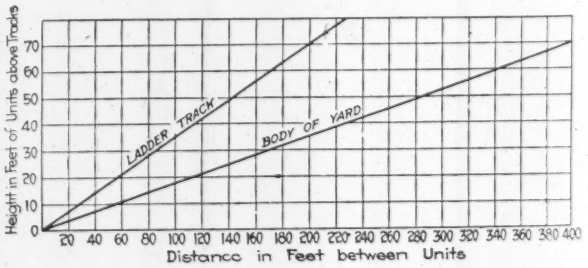


FIG. 2. DIAGRAM FOR HEIGHT AND SPACING OF LIGHTS IN CLASSIFICATION YARDS

as possible thrown under the car. There should be a row of lights in each space between the tracks, with a height of 16 ft. and a spacing of about 30 ft. Tungsten lamps of 100 or 200 watts are best for this service, with a shallow dome reflector that covers the filament to about 10° below the horizontal. For storage yards, all that is needed is general illumination sufficient to permit safe passage among the cars and to discourage lawlessness. A system similar to that recommended for the body of a classification yard is satisfactory, although a lower intensity of illumination may be permitted. Another method is to use searchlights or projectors at one or both ends of the yard, throwing the light down between the rows of cars, but this is objectionable on account of the glare.

Flood lighting for yards was suggested in the discussion. W. J. Davis, of the American Lighting Co., considered this system efficient and economical for freight

yards, and probably superior to other systems. At each end of the yard would be a battery of flood-light units, at a height of not less than 75 ft., and so mounted that the beam of light would be practically horizontal. This arrangement would flood the whole yard with a soft and uniform light. On the other hand, J. L. Minick, Pennsylvania R.R., did not consider this system suitable for general use. In classification yards, for instance, spot lighting for each switch is necessary, and flood lighting would not meet the requirements.

How To Save the Horseshoe Fall at Niagara

That the great Horseshoe Fall on the Canadian side of the Niagara River appears to be delivering now a much smaller volume of water than it did a score of years or more ago, is the testimony of many observers. The responsibility for the diminution in the great cataract has been almost universally laid upon the diversion of water from the river for use in power development. Based on the general acceptance of this theory, a powerful body of public opinion has been arrayed against the proposition to divert additional amounts of water from the cataract for power development.

This opposition has been so influential that there has been general acceptance of the idea that further diversion should not be permitted; and for the past three or four years attention has been directed to schemes for obtaining power from other sources at Niagara, such as the Whirlpool Rapids below the falls.

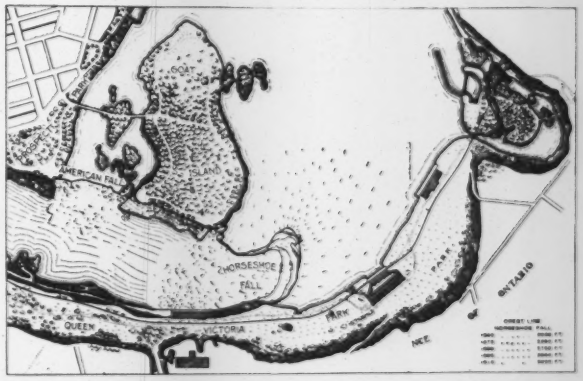
John Lyell Harper, a well-known engineer, has just published a pamphlet entitled "The Suicide of the Horseshoe Fall," in which he maintains that the apparent diminution in the flow of water over the Horseshoe Fall is not due chiefly to the comparatively small percentage of water diverted for power purposes, but to gradual changes in the contour of the precipice over which the water flows, the effect of which is to concentrate the flow in the center of the river so that a much smaller proportion than formerly is discharged over the precipice at the sides of the fall.

The accompanying drawing, reproduced from Mr. Harper's pamphlet, makes apparent the great changes which have taken place in the outline of the Horseshoe Fall during the past 75 years. While the precipice on the Goat Island side is practically unchanged, the rapid erosion going on at the toe of the horseshoe has moved the precipice at that part of the fall a considerable distance upstream.

The visitor at Niagara who views the fall from Goat Island now sees a huge mass of solid green water plunging over the precipice at the toe of the horseshoe, while only a thin veil of water flows over at the sides. It is obvious that with the concentration of the flow in the center of the stream, erosion there tends continually to become more and more rapid, and the concentration of flow at that point becomes still greater. Mr. Harper says:

> **An entire cessation of the diversion of water from the river for power would not retard the self-destruction of the horseshoe form, but would rather tend to accelerate it. No negative action can preserve the horseshoe, but positive action must be taken with courage and intelligence, and as soon as possible, so that the greatest scenic spectacle in the United States may not be allowed to commit suicide.**
>
> **It should be the policy of those controlling the falls at Niagara to have constructed in the bed of the river, above the Horseshoe Fall, invisible current deflectors which would make impossible the gathering of the whole river into a deep narrow gorge, and would again deflect the water over to the sides and heels of a reëstablished horseshoe. This would not only improve the present spectacle, but would cause the whole contour of the fall to wear uniformly, so that coming generations in viewing its beauty may also have before their eyes the emblem of good luck.**

Mr. Harper further points out that the American Fall, on the eastern side of Goat Island, delivers only 5% of the total flow of the river, yet it forms at least a quarter of the total scenic spectacle. If the flow of the river in the Canadian channel were spread around the whole length of the horseshoe, as it is along the crest of the American Fall, Mr. Harper believes that not more than 35% of the total discharge of the river so distributed



CATARACT AT NIAGARA SHOWING THE RECESSION OF THE HORSESHOE FALL SINCE 1842

LENGTH OF CREST LINE OF HORSESHOE FALL

1842	2,030 ft.
1875	2,350 ft.
1890	2,750 ft.
1905	2,850 ft.
1916	3,020 ft.

would cover the entire precipice at the Horseshoe Fall with a cascade more than twice as deep as that of the present American Fall, and would produce a scenic effect equal in grandeur and greater in extent than the present fall.

Mr. Harper is Chief Engineer of the Hydraulic Power Co. of Niagara, and is a member of the American Societies of Mechanical Engineers, Civil Engineers, and Electrical Engineers, and the electrochemical society. He makes no suggestion in his pamphlet as to the methods by which the "invisible current deflectors" which he proposes could be constructed in the bed of the river above the Horseshoe Fall. Those who have visited Niagara and witnessed the wild torrent of water which sweeps down the rapids above the falls can form a conception of the heroic task that would be involved in building any structure in those seething waters which could withstand them.

The importance of the matter brought forward by Mr. Harper, however, certainly challenges attention. No one will seriously question the desirability of utilizing Niagara's power as a great national or international resource, so far as it can be done without serious interference with its beauty as a spectacle. Even an amateur in hydraulic engineering can see that Mr. Harper's diagnosis of the chief cause of the lessening in beauty of the Horseshoe Fall has every element of probability in its favor; and it is evident that the deterioration of the fall is likely to proceed at an accelerated pace unless something is done to restore the conditions of a century ago.

Notes from Field and Office

Illustrations of piledrivers built by railways—Dynamite increases flow of well from 3⅓ to 22 gal. per min.—Concreting train for street-railway work—Improvised dragline—Simple azimuth determination—Placing assembled coffer-dam—Heavy haulage for tractor

Piledrivers Designed and Built by Three Railways

The two general types of track piledrivers are the turntable driver and the boom driver. A turntable driver, designed and built by the Engineering Department of the Chicago, Milwaukee & St. Paul Ry., has as a special feature a pair of rockers which serve as a support for the leads while they are being raised and lowered. This piledriver is self-contained, no idler car being required during transportation. The forward reach is 18 ft. and the side reach 20 ft. This driver is used with both steam and drop hammers. It is illustrated in Fig. 4 (right-hand) equipped with a 4,000-lb. drop hammer and 65-ft. leads.

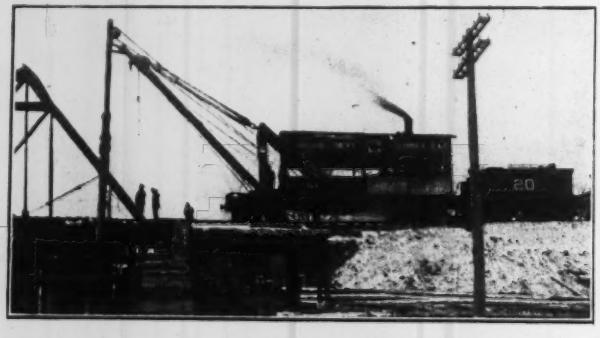


FIG. 1. OLD STYLE DERRICK CAR AND PILEDRIVER X-20 OF ILLINOIS CENTRAL

Horn connection on boom end holds lead to boom when driving piles. Lifting capacity of 15 tons. Data from A. S. Baldwin, Chief Engineer, I. C. R.R.

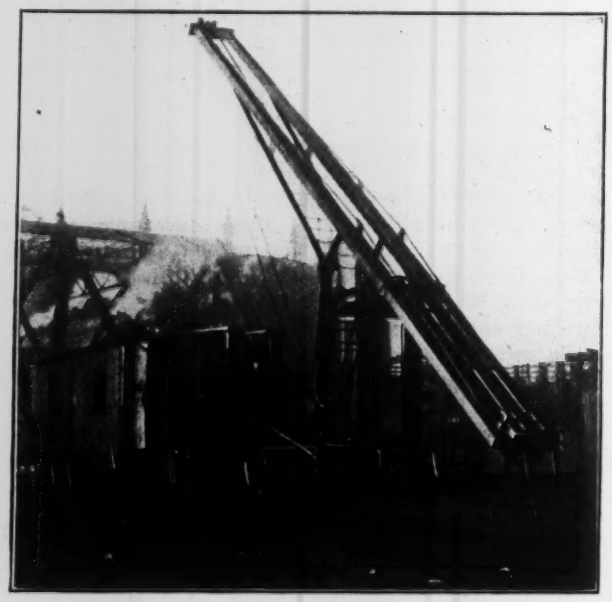


FIG. 2. GRAND TRUNK PILEDRIVER BUILT OF OLD-BRIDGE MEMBERS

Photograph from H. R. Safford, Chief Engineer, Grand Trunk Ry. System, Montreal

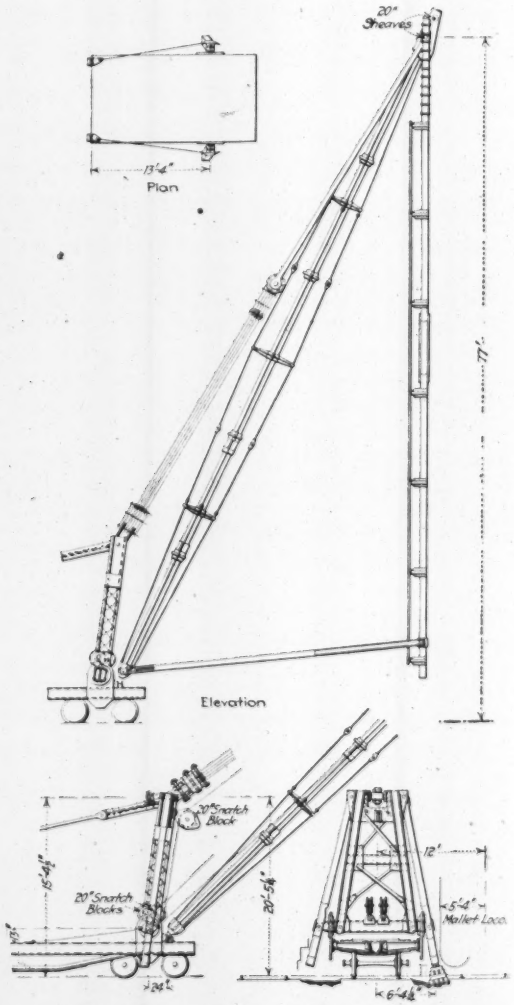


FIG. 3. BUSINESS END OF MILWAUKEE PILEDRIVER WITH PENDULUM LEADS FOR LONG PILES

Data furnished by C. F. Loweth, Chief Engineer, Chicago, Milwaukee & St. Paul Railway Co.

The Grand Trunk Ry. also is using piledrivers of its own design and built in the company shops. Fig. 2 shows this. An auxiliary deck, swinging about the center of the car, carries leads, boiler and engine. The leads may be raised or lowered, by shifting the hammer. The

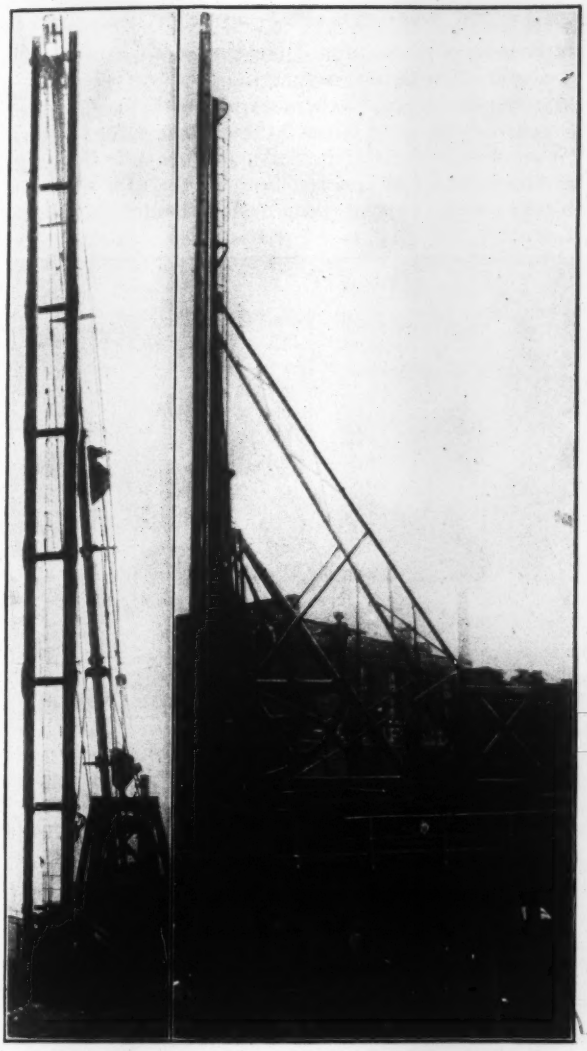


FIG. 4. MILWAUKEE DERRICK CAR EQUIPPED WITH 76-FT. (LEFT VIEW) AND 65-FT. (RIGHT) LEADS

Photographs from C. F. Loweth, Chief Engineer, C. M. & St P. Ry., Chicago

driver can be moved in a half-minute after driving has stopped. The car is propelled by double reversible engines attached to the underside of the car sills and connected to the axles. It is equipped with airbrakes.

Good examples of the boom type of piledriver are in use on the Illinois Central R.R., having been designed and built by that company. These are really bridge erection derricks, and are used to considerable extent for that purpose and for handling and unloading heavy material. The piledriving equipment consists of a set of leads swung from the end of a 40-ft. boom for use with drop hammers and a 50-ft. boom for use with steam hammers. Piles may be driven 30 ft. ahead of the forward axle and 21 ft. from the center of the track, provided an outrigger, consisting of block-and-fall, is put out on the opposite side. The latest of these cars are built of steel, with the exception of the floor and house. They are equipped with chain propellers and air brakes, and some of them have sufficient air capacity to operate pneumatic tools.

Another rig of the kind just described was designed for driving 70-ft. foundation piles on the Chicago, Milwaukee & St. Paul Ry. The boom is of steel pipe, while the 76-ft. leads are pin-connected at the top and connected to the bottom of the boom by an adjustable steel frame. With this equipment thirty long piles could be driven in a 10-hr. shift. It is illustrated in the left-hand view of Fig. 4.

Dynamiting a Deep Well To Increase the Flow

A water well near Kennett Square, Penn., was "shot" a short time ago to increase the flow. It was 600 ft. deep, started at the top of a hill of elevation 460 ft. G. F. Alderson, Kennett Square, describes the work in *Engineering and Mining Journal*. After drilling through 84 ft. of stiff clay and hardpan, solid rock was encountered with successive strata as follows:

	Ft.		Ft.
Sand rock	121 0	Gray granite with green serpentine seams	2 0
Flint rock	90 0	Gray granite	40 0
Blue granite	17 5	Blue granite	3 0
White quartz	1 2	Gray granite	72 0
Gray granite	47 8	Bastard granite	84 0
Blue granite	17 5		
Gray granite with quartz seams	10 0		
Blue granite broken	10 0	Total	516 0

An 8-in. steel casing was sunk to rock and grouted to exclude surface drainage; the hole through the rock was 6 in. At 600 ft. the flow was measured and found to be only 3⅓ gal. per min. To go deeper would mean expensive pumping equipment. It was thought that a discharge of nitroglycerin would shatter some of the water-bearing strata.

Indications were that the stream supplying the well was about 320 ft. below ground level. Just below this point the well was bridged by means of a ball of stiff wire forced to the desired depth. Concrete was placed upon this. Mr. Alderson describes the shooting, as follows: "A special type of solidified nitroglycerin—which is commonly used for shooting oil wells—formed the charge, which consisted of 190 qt. The explosive was packed in 10 tubes, 5¾ in. in diameter and 7 ft. long. These were placed in the well one above another, and the whole was discharged by dropping a jack squib down the well.

A column of water 500 ft. high was blown from the well, following which the latter was tested. The test pump working continuously for 7 hr. pumped 10,000 gal., which was at the rate of 22 gal. per min.

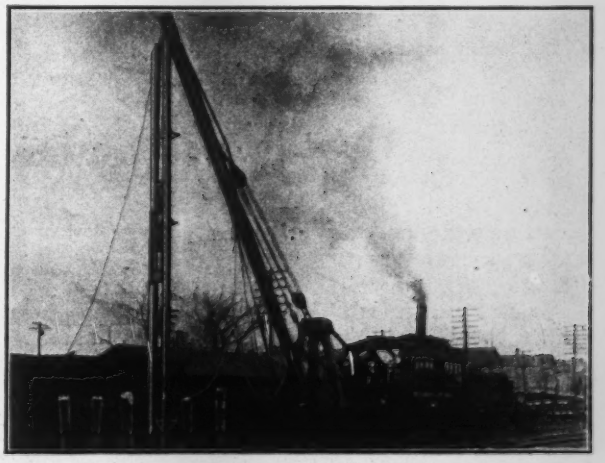


FIG. 5. STANDARD STEEL PILEDRIVER OF ILLINOIS CENTRAL R.R.

Leads are connected on end of boom by a pair of lugs and bolts. Machine (X-24) has lifting capacity of 35 tons and one or two steam hammers can be operated; capacity is 40 wood piles or 35 concrete piles per day. Data furnished by A. S. Baldwin, Chief Engineer, Illinois Central R.R.

Concreting Train for Street-Railway Work

A concreting train of specially interesting design is used by the Detroit United Ry. for building the concrete base for tracks in paved streets at Detroit, Mich.

At the rear end of the train is a 35-ft. steel-frame motor car carrying a 2-yd. mixer of the drum type. The forward end of this car is an inclined bucket elevator, which receives the material from the conveyor belt noted below and delivers it to a charging hopper.

The mixer car is shown in Fig. 2 with the converter and one of the gravel cars at the right. At one end of the upper deck is a standard carrying a trolley pole. At the opposite end is a platform for the men who control the supply of aggregate, feed the water and dump

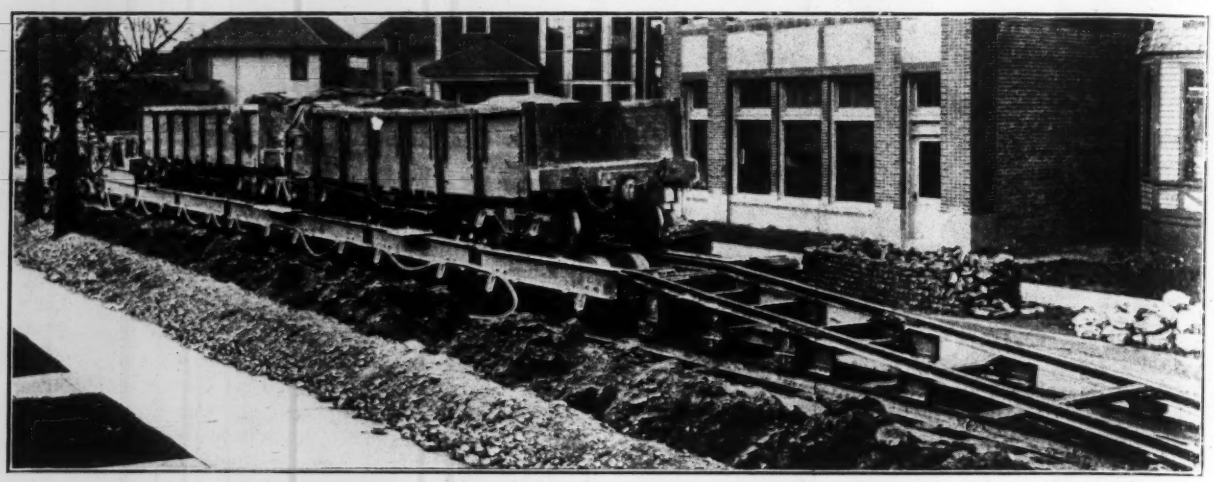


FIG. 1. MATERIAL END OF CONCRETING TRAIN AT DETROIT
The two cars drop gravel upon a belt conveyor which delivers the material to the mixer car at the left

charging side is inclosed in order to avoid dust from the cement, etc. On the discharge side the concrete is delivered into an inclined chute and deposited between the rails, directly under the center of the mixer. At the the cement into the hopper. There are two men on the mixer car.

The forward end of the train consists of a series of seven four-wheel steel-frame trucks carrying a belt con-

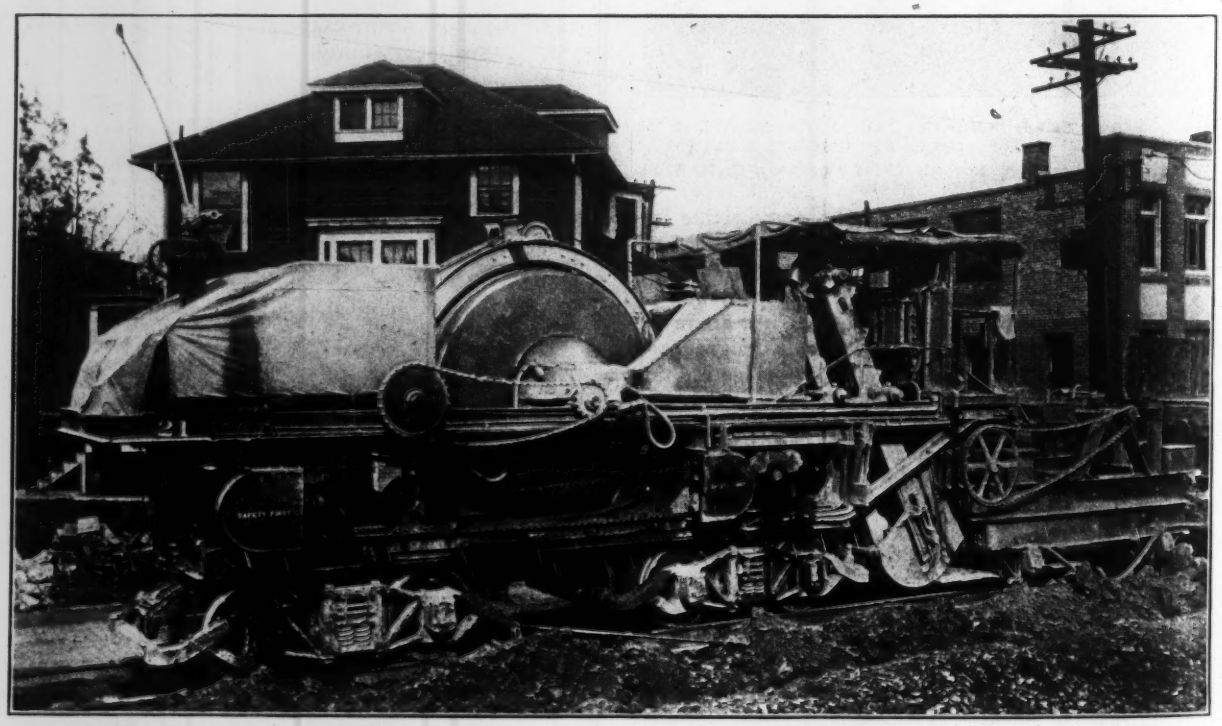


FIG. 2. MIXER CAR OF CONCRETING TRAIN ON THE DETROIT STREET RAILWAYS
Next to this car is a truck carrying the head of a conveyor belt which travels under the dump car shown at the extreme right

veyor 36 in. wide and 80 ft. long. They also carry a standard-gage track, the end of which is connected with the surface track by an incline (with inclination of 1 in 3) supported by structural-steel frames. Feather rails, resting on the surface track rails, form the forward end of the incline. This part of the concreting train is shown in Fig. 1. The rear truck of the portable conveyor (which is next to the mixer car) carries the driving mechanism and the tripper or chute for discharging the material from the end of the conveyor belt, as shown at the right in Fig. 2.

The track being blocked up to grade, the train is run upon it. A motor car then pushes onto the track over the portable conveyor two hopper-bottom gondola cars, each holding about 30 yd. of graded gravel and sand. The hoppers are opened gradually, and the contents fall upon the conveyor belt. This delivers the material to the elevator, which in turn delivers it to the charging hopper. This supply is sufficient for one shift, and between the shifts empty cars are removed and loaded ones put in place.

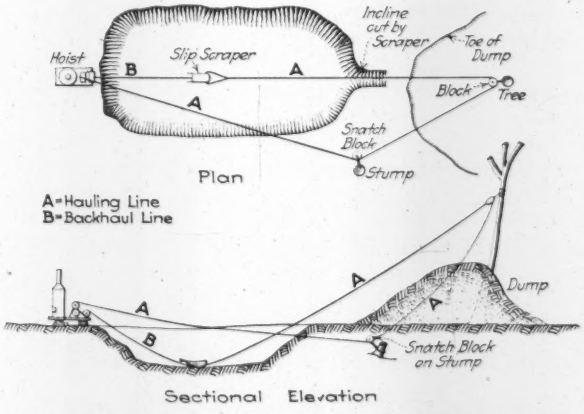
As the concrete is spouted into place, the train backs away, and the concrete is dressed to surface and floated by hand. This outfit is used also to place the concrete filling between ties, after the track is completed.

The car has two 80-hp. motors on each truck, and an 80-hp. motor that drives the mixer, elevator and belt conveyor by means of sprocket chains. With this outfit about 350 cu.yd. of concrete can be placed in a 10-hr. working day. There is a crew of 11 men with the train.

The plant was designed by John Kerwin, Superintendent of Tracks, Detroit United Ry., and was built at the company's track-department shops under his direction.

Improvised Dragline Rig

In excavating the foundation pit for a set of floodgates in the Brevoort levee, in Indiana, the contractor rigged up a dragline outfit, as shown in the accompanying sketch. A hoisting engine was placed at one side of the pit, with a backhaul cable hitched to an ordinary



IMPROVISED DRAGLINE RIG FOR FOUNDATION-PIT EXCAVATION

slip scraper. The hauling line was run clear of the pit through a snatchblock at one side and then up to a block attached to a tree in line with the hoisting engine, from which the cable led back to a bail on the scraper.

Men in the pit held the scraper by its handles to give it a load and start it up the incline, which it cut for itself. One man was stationed on the dump. Some trouble was experienced in dumping, but on the whole the rig worked very well; as the excavation was small, nothing more elaborate was needed. The material was a soft and wet but very sticky mud, in which the men worked with difficulty, both in the pit and on the dump. The engineer was J. S. Spiker, of Vincennes, Ind., and the Vincennes Bridge Co. had the contract for the drainage outlet, including the concrete work and gates.

Simple Azimuth Determinations

By J. K. Finch*

The writer desires to call attention to the computation of azimuth by direct solar observation, described in "Field Book Sheet for Azimuth," in *Engineering News*, Aug. 24, 1916. This method is gradually coming into more extended use in general surveying practice, as it gives a sufficiently exact result (about $\pm 1'$) without the necessity of staying in the field over night for a Polaris observation at elongation. It is also preferable to using a solar attachment, when only one or two determinations of azimuth are required. It seems, however, that many surveyors are deterred from using it owing to the somewhat formidable-looking formula advocated in most textbooks and also in the article above mentioned.

At the Columbia University summer school of surveying, Camp Columbia, we have required students to use all three methods and, in computing azimuth from a direct observation, have used the following formula:

$$Cos\ A = \frac{sin\ d}{cos\ l\ cos\ h} - tan\ l\ tan\ h$$

where A is the bearing of the sun (the sign of A from the computation determines the quadrant; thus if A is plus in the forenoon the bearing is N.E., if minus S.E.; and similarly in the afternoon, N.W. and S.W.); and d = declination; h = observed altitude; and l = latitude.

This formula not only has the advantage of lending itself to simple logarithmic computation, but does not involve all the additions and subtractions that are required in the usual formula.

The following example illustrates the form of computation:

	Angles	Anti-Logs	Logs	
l	41° 03′ 45″	.....	Log cos = 9.87737	Log tan = 9.94012
h	26° 11′ 15″	.....	Log cos = 9.95297	Log tan = 9.69178
			Sum = 9.83034	
d	—20° 49′ 37″	.....	Log sin = 9.55090	
		—0.52549	Diff. = 9.72056	
		0.42845	.....	Sum = 9.63190
A	S 17° 27′ 30″ E	—0.95394 = diff. = nat. cos A.		

Due attention must be paid to the sign of the declination, which determines the sign of the first term of the equation.

This formula will be found on p. 223 of the "Standard Field Tables of the General Land Office, U. S. A." A modification of the same formula was proposed in *Engineering News*, Mar. 6, 1913, in an article by Louis Ross.

[The formula quoted by Professor Finch is given and explained in Johnson's "Theory and Practice of Surveying," seventeenth edition, p. 99, and it is in pretty general use in the West, where surveyors are required to make frequent azimuth determinations in surveys and resurveys in the location of section and quarter-section corners.

*Department of Civil Engineering, Columbia University, New York City.

The "Standard Field Tables of the General Land Office," referred to by the author, is a pocket-book that should be in the hands of every surveyor. While primarily designed as an aid in public-land surveying, the tables are of the utmost value to all surveyors.

Inquiry is frequently made for traverse tables. This book, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 60c., contains latitudes and departures to four places for each ¼°, for distances 1 to 100. There are also tables of stadia coefficients, of natural sines, cosines, tangents and cotangents, logarithmic tables of trigonometric functions and of numbers, besides tables and formulas for astronomical work.—Editor.]

Placing Wood Coffer-Dams Without Driving

By K. H. Shriver*

An interesting method of building wood coffer-dams is being used at dam 24, Ohio River, by the Sheridan Kirk Contract Co. These coffer-dams are known as the box type and are 20 ft. wide inside sheeting, at an elevation of 16 ft. above low water.

The method of procedure is as follows: A framework of wales and vertical posts, consisting of five panels 17 ft.

SETTING COFFER-DAMS; TIMBER FRAME SUSPENDED, AND COFFER-DAM IN PLACE, DAM 24, OHIO

long, is built on a decked barge, which is towed to the site; the frame is raised by two derrick boats, and after connecting to the preceding section it is lowered to the bottom of the river. The sheeting is then placed and spiked to the wales, and the coffer-dam is filled to a depth of 5 ft. with material excavated from the river.

The remaining two rows of wale timber are then placed and bolted, and the sheeting is cut off to grade, when the balance of the fill is made and leveled to the top of the sheeting.

The frame is made up of two rows of wales on each side, 3 ft. and 8 ft. from the bottom, bolted to 2x12 vertical posts, spaced 8½ ft. c. to c., resting on a decked barge 24x100 ft. The wales are 6x8's, 18 ft. long, having a 6-in. lap joint; the rods ⅞-in. round, 22 ft. long. The struts or spreaders are 2x12's, 20 ft. long. They are placed directly above each rod and cross-braced.

The lifting tackle consists of two slings, each made up of six lines of ¾-in. steel cable, which are made fast to the top wale at each upright. The work is being done under the direction of Maj. T. H. Jackson, Corps of Engineers, U. S. A.; E. H. Groot, Junior Engineer, is Assistant in Charge for the Government.

*Junior Engineer, United States Engineer Office, Racine, Ohio.

Heavy Haulage for Tractor and Trailers

Following a series of tests, tractors and trailers are now hauling ore from the Cardiff mines in the Big Cottonwood district of Utah in place of hundreds of teams formerly employed to haul the ore to the smelters in the

TRACTOR AND TRAILERS ON DOWNGRADE FROM CARDIFF MINES IN UTAH

valley and bring back coal and other supplies. Eleven demonstration trips were made by a tractor with trailers, under the direction of L. B. Stone, the data thus collected being published in the *Salt Lake Mining Review*. The equipment consisted of one Model 36 Knox tractor having a 5-ton ore body and two 5-ton Troy trailers equipped with steering apparatus, roller bearings and 36x7-in. rubber tires. On the down trips from the mine the trailers were held back by the brake on the tractor, even on grades as steep as 16%. The tractor treads were steel, 14 in. wide and fitted with diagonal cleats.

On the 11 trial trips 272,660 lb. of ore was hauled, and 27,080 lb. of coal was transported from the valley to the mines, the average amount of coal per trip being two tons.

The gasoline consumption was 21 gal. per round trip, and the round-trip consumption of oil averaged 2 qt. The distance covered on each trip down comprised 9 mi. in the cañon proper and 7 mi. across the valley, the latter strip including one steep hill. The vertical lift in the 16-mi. journey is 3,050 ft. It is notable that the radiator did not overheat.

Large Engine Crank Welded at Pumping Station

The cast-steel drag-crank web of a 20,000,000-gal. pump at Queen Lane Pumping Station, Philadelphia, found to have a fracture starting at the inside corner of the rectangular hole and extending all the way across the web on an angle of 45°, in a cross-section measuring 8x8½ in., was "Thermit"-welded in place without having to remove the crank from the engine, which operation would have entailed considerable labor. John H. Burt

Superintendent of the city shops, describes this work in the house organ of the Goldschmidt Thermit Co. At the same time this weld was to be made it was decided to install a later-type drag crankpin of 12-in. diameter, and the shops worked day and night making this pin while the old pin was being drilled out and a slot 1⅛ in. wide was being drilled for welding purposes through the fractured web.

The position of the fracture in the web made welding difficult, as it was desired to have the riser on the outside of the web to insure that the best material would be in the hole that carries the drag-crank check plates. This made it necessary to turn the crank at an angle of 45°, and this operation had to be performed at some depth in the crank pit. To do this a working floor was built in the pit.

The crankshaft itself was 18 in. in diameter and it turned in babbitted bearings, one of which was against the face of the broken web. To prevent the heat from injuring the babbitted bearing the crankshaft was raised ⅜ in., and a stream of water was played on the metal.

It was expected that 8 or 10 hr. would be required to preheat the crank, but after the burners had been blazing away for 8 hr., it was found that although the crank web was at red heat, the heavy portion of the web was black. Asbestos, 1½ in. thick, was then placed over all of the exposed portion of the crank web to reduce radiation, and 2 hr. later the thicker part began to glow; in 4 hr. a good working heat was attained.

At 11 p.m. 250 lb. of "Thermit" was ignited, and at 3:30 a.m. flask and sand were removed. The weld was excellent, and the riser and gates were cut off and the hole finished out, when the new crankpin was shrunk in the opposite web.

To Mark a Brown Print White

An inquiry was published in *Engineering News*, Nov. 23, as to what solution will mark a van dyke white. I wanted to know this myself a short time ago, so I went into the laboratory and tried soda, ammonia carbonates, acids and peroxide, but could find no single solution that would bleach out the brown. In drawing lines with the pen, however, I discovered that at the intersection of some of them the print turned white. A mixture of these two was made and a clear white surface was left under brush or pen.

The two substances are hydrochloric acid and peroxide of hydrogen. No treatment seemed to be needed after applying the solution. EDWARD GODFREY.

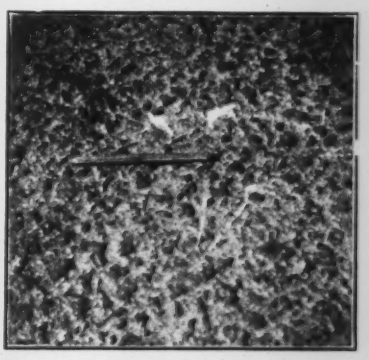
Monongahela Bank Bldg., Pittsburgh, Penn.

Rough-Surface Asphalt Paving

A new type of asphalt pavement, constructed by the penetration method, is being tried out by the Massachusetts State Highway Commission on some roads in the third division, where F. C. Pillsbury is division engineer. The purpose is to devise a bituminous surface suitable for hillside paving, where there is considerable horse-drawn traffic, for there has been a pretty widespread complaint over the slipperiness of the various forms of bituminous road surfacing used in the state.

The construction of this pavement differs from the regular bituminous macadam road constructed by the penetration method in that all the asphalt is applied at one and the same time. No seal coat or second application is made.

The pavement is constructed by spreading a layer of No. 1 stone (passing 3-in. and retained on 2-in. circular opening) to such thickness that it will roll down to a depth of 3 in., and then applying 2¾ to 3 gal. of hot asphalt per square yard, in one application, as already noted. The resulting pavement is very rough, with projecting stones, as shown in the accompanying illustration. Pavements of this type have been in use for about a year without showing any tendency to ravel or of the stones to loosen. In any but icy weather the surface offers a good footing for horses, and motor vehicles do not skid on it.



ROUGH SURFACE ASPHALT PAVEMENT

Many special types of bituminous road construction have been developed in this state, but the cheapest and most satisfactory for moderate traffic conditions appears to be a hot mixed gravel and asphalt. During the past season some special apparatus, including a 20-ft. portable drying drum, has been developed for constructing this type of road.

The chairman of the Massachusetts State Highway Commission is William D. Sohier, and the chief engineer is A. W. Dean.

Tunnel Surveying by String Where Transit Failed

BY A. L. PLIMPTON*

The article on "East River Tunnel Surveys," by C. M. Holland, in *Engineering News* of Oct. 5, 1916, brings to mind the survey experience that was had in the work of constructing the Boston main drainage system about 35 years ago in connection with giving the line for the tunnel under Dorchester Bay.

This tunnel, one of the very first that was ever constructed under the sea for sewerage purposes, was about 1⅓ mi. in length and about 140 ft. below low water. To facilitate its construction there were three working shafts about 3,000 ft. apart. The line had to be dropped down the shaft in each case and then was extended from the very short length thus obtained into the headings.

At the outset the usual method by means of a transit was followed. As the work progressed, greater and greater difficulty was experienced in giving sights on account of fog and smoke, which could not be driven out.

Finally, one of the headings was in so far beyond where accurate line had been determined that it had become a very serious matter, and still the transit could not be used. It was then decided to try and see what could be done by the mechanic's method of stretching a line. The scales

*Civil Engineer, Boston, Mass.

in the roof for recording the position of the line were about 300 ft. apart, which meant stretching a line for about 600 ft. in order to locate a new scale.

The finest trout line was purchased, at a cost of about $7, and the party went down to see what could be done. It was found that it was impossible to stretch it so as to lift it off the bottom without breaking it, as it would not hold its own weight. The writer, who was one of the engineering corps, happened to have a ball of linen thread and suggested trying that the next time in place of the trout line. This was done, and its strength was such in relation to its weight that it could be pulled so that the sag was not more than 4 ft. It looked as though something could be done by using 10c. worth of thread in place of the trout line.

Posts were wedged between roof and bottom (so as to be absolutely solid), one back of what we will call Scale 1, and the other beyond, toward the heading, where Scale 3 was to be placed; No. 2 scale was midway. No attempt was made to place Scale 3 accurately, but care was taken merely to have the line come somewhere near the middle of it, as shown by the thread held approximately on line. After the scale was secured in place, the thread was stretched and fastened on one side of the posts, and careful readings were taken at each of the three scales. This was done in the following manner:

There was a sliding vernier on each scale, and a tiny plumb-bob was suspended from the vernier so as almost to touch the thread. A little silver plumb-bob that had been made for a watch charm was used for the purpose. The observer gave directions to his assistant how to move the vernier by placing himself so as to note the final coincidence in a vertical plane of the stretched thread and the line to the plumb-bob, which were both illuminated equally on each side by candle light. It was perfectly surprising with what accuracy the vernier could be moved off of line and again set by the same or by a different observer, by this method. It must be understood that the conditions were perfect for this kind of work, as it was absolutely still down there in the bowels of the earth, not a current of air to disturb the line or the plummet.

When several readings had been taken with the thread on one side of the 3x4-in. upright posts, it was changed to the other side of the posts and a new set of readings taken. The exact position of the center line on the new scale was then worked out in the office on cross-section paper.

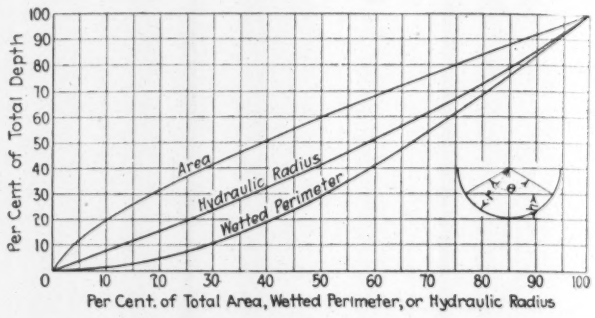
The agreement of the results of the two lines run in determining the position of the center line on the new scale was so perfect that this method was followed all through in the work of the tunnel, even at the outset while working from a new shaft when a transit could have been used.

And thus instead of its being the difficult and long operation of trying to set a transit up on line and sighting under all sorts of atmospheric conditions, it was a perfectly definite method of procedure in each case, and one which took but little time. When the work was completed, the thread was cut down and left there; and the party came out, with the feeling that they had got results.

The headings in each case met with very slight error, the greater part of which was undoubtedly due to the error in transferring the line down the shafts and not to extending it.

FINE AGGREGATE

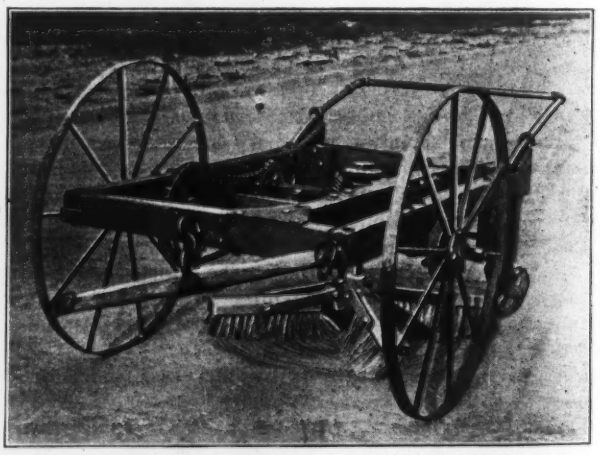
Curve for Design of Semicircular Flumes—The computation of the area and hydraulic radius for any given depth of water in a semicircular flume requires the use of somewhat long and complicated formulas. The accompanying curve gives the percentage of total area, hydraulic radius, or wetted perimeter for any percentage of total depth. The total area and the full-depth hydraulic radius for various diameters are



CURVE FOR SEMICIRCULAR-FLUME COMPUTATIONS

generally given in the catalogs of the various flume companies or can be obtained from the "functions of numbers" tables in any handbook. The computation of A and r for fractional depths then becomes, by means of this curve and a slide rule, a very simple matter.—Lewis M. Hammond, Assistant Engineer, United States Reclamation Service, Provo, Utah.

A Sand-Spreading Device for filling joints in an asphalt-block pavement is shown herewith. It was used by the Asphalt Block Paving Co., Toledo, Ohio, on Shaker Boulevard between North Moreland and Coventry, suburbs of Cleveland, Ohio. The device consists of four ordinary street brooms,



DEVICE FOR FILLING JOINTS IN ASPHALT-BLOCK PAVEMENT WITH SAND

fastened to arms at right angles to each other, which revolve as the two-wheel truck is moved. The driving mechanism is a sprocket and chain attached to the axle, which operates a pair of bevel gears through another sprocket and shaft. The carriage is intended to be drawn by a horse. Obviously, the same device could be used for spreading grout on other block pavements.

Topographic Surveys by the U. S. Geological Survey have now covered 41% of the entire area of the country, according to the annual report of Secretary Lane, of the Department of the Interior. During the year ending June 30, 1916, 22,715 sq.mi. were mapped topographically, making the total area in the United States surveyed to date 1,237,520 sq.mi. Topographic surveys were made in 29 states, 17 of which cooperated in the work. In the Division of Water Resources 1,302 river gaging stations were maintained in 1916.

Editorials

Engineering News as a Christmas Present

One of the pleasures which come to the subscription department of *Engineering News* at each recurring annual season of Christmas cheer and good will is the letters received from those who desire to give a year's subscription to *Engineering News* as a present to some friend.

These letters come from many different sources. Many are from mothers who desire to send to a son engaged in engineering work a present that will be at once a help in his daily tasks and a weekly reminder of the giver. Others are from wives who wish the paper sent to their husbands—a class of subscriptions especially noteworthy as conclusive proof of conjugal affection, for wives with engineer husbands are generally thoroughly familiar with the usual desire of engineers to preserve the back numbers and back volumes of *Engineering News* for reference, and realize even better than their husbands what this means in demands on space and necessity of handling and dusting.

Still other remittances come from manufacturing and business firms who desire to present a year's subscription for *Engineering News* to some of their employees.

The rapidly growing custom of widespread distribution of Christmas presents is in danger of self-destruction because of the too-common practice of giving as a matter of obligation instead of giving in the Christmas spirit of good will, and also because of the too-common practice of giving presents which are for show rather than use and which the recipient is puzzled to know what to do with.

At this time of world-wide scarcity and countless appeals to one's sympathy and purse, it is surely an appropriate time to cut out presents of the useless order and to substitute in their place presents like that suggested above, which are a direct help to the recipient in his daily work.

Letting Contracts on the Cost-Plus-a-Percentage Basis

The unprecedented conditions in the labor and material market at the present time have given a great stimulus to the plan of letting contracts on a cost-plus-a-percentage basis, instead of at a fixed price. A notable example is the contract for which bids were opened last week for the construction of four battle cruisers for the United States Navy. These vessels are to be very much larger and faster than any vessels ever built in an American shipyard. They are to have six times as much horsepower, and are to develop 14 knots higher speed than the largest vessel hitherto built for the United States Navy. In the act authorizing these vessels, on account of their more or less experimental character, Congress provided that the Secretary might at his discretion let contracts for them on a cost-plus-a-percentage basis.

In the bids submitted last week by the Union Iron Works of San Francisco and the Fore River Shipbuilding Corporation of Quincy, Mass., both concerns pointed out that their reasons for submitting their bids in the form of cost plus a percentage was not alone the novel character of the vessels, but the great uncertainty as to prices which will govern for material and labor during the construction of the vessels. It is estimated that these vessels will require at least four years to construct, and no one on earth is wise enough to predict with any accuracy what the prices of labor and of steel will be even twelve months hence.

Under ordinary conditions, a contractor in submitting bids makes contracts in advance with the concerns which are to supply materials, etc., so that he can know definitely in advance what the cost of the material will be. The Union Iron Works in submitting its bid declared that it had found it impossible under present market conditions to cover by option or provisional contract a large percentage of the material required for the battle cruiser. Such estimates for the vessels as have been prepared show a cost which will already considerably exceed the appropriation made by Congress.

The conditions cited in connection with this huge contract are typical of conditions existing in connection with nearly all contracts at the present day. Concerns with a good reputation and financial responsibility are not inclined to endanger their solvency by making close bids on work when it is necessary to run the risk that materials and labor both may increase in price 10, 20, or 30%, or even more during the period while the construction is in progress, and the added risk that difficulty in obtaining materials or labor may delay the completion and subject them to a penalty. Under these conditions the interests of the taxpayers will generally be better served by letting contracts for public work on a cost-plus-a-percentage basis wherever the law will permit this, than on the usual fixed sum basis.

Engineering Work and State Highway Legislation

The American Highway Association has rendered a useful public service by issuing at this time, shortly before the assembling of most state legislatures, a review of legislation concerning state highway departments. The review has been prepared by R. Walter Moore, Chairman of the Association's Committee on Legislation.

It is to be hoped that one particular sentence in this review will be read and taken to heart by the legislators in whose hands it will be placed. Under the heading "Engineering Work," Mr. Moore says: "No state highway department can be of more than nominal service without a capable engineering bureau."

To members of the engineering profession this may sound like a platitude; but any one familiar with the conditions under which country highway work is done knows that there is a deep grounded opposition in many

parts of the country to the employment of an engineer in connection with highway work, or what amounts to the same thing, to the payment of salaries sufficient to enable competent engineering service to be secured.

In order to make certain that the technical work of a state highway department shall be under the direction of a competent engineer, it is recommended that unless some member of the state highway commission is required by the law to be an engineer, a clause should be inserted in the law reading:

> The state highway commission shall appoint a state highway engineer, who shall be a competent civil engineer, experienced and skilled in highway construction. He may appoint, subject to the approval of the commission, such technical assistants as may be necessary for the proper conduct of the engineering work of the commission.

In connection with the engineering work of state highway departments, sharp criticism is made for the indefinite responsibility at present existing for the safety of highway bridges. Recommendation is made that legislation should be enacted providing that all bridges on roads built or maintained with the aid of state funds shall be inspected annually by the state highway department which should also inspect all bridges of more than 20 ft. span on roads not built or maintained with the aid of state funds. Any bridge found to be unsafe should be immediately posted by the state highway authorities, which should serve notices on the local authorities responsible for the bridge ordering them to make necessary repairs, and in case of failure to make such repairs reporting the case to the Attorney General.

In reviewing the organization of state highway departments, Mr. Moore unfortunately fails to make clear the great advantage in having state highway commissions made up of three or more members, with the term of office of only one member at a time expiring. Under such a commission a continuous organization is generally maintained and the periodical "clean sweeps" are avoided, which experience has shown are only too apt to occur when a state highway department is in charge of one man. The advantage of maintaining a continuous organization is obvious to all members of the engineering profession and ought to be made clear to the general public.

Combinations for Conservation of Natural Resources

Eight years ago the attention of the public was effectively directed toward the need of conservation of the Nation's resources, by the famous Conservation Congress held at the White House. That notable meeting, however, made only a beginning in the necessary work of public education. Since that meeting, some of the leaders in the conservation movement have diverted it from its original great purpose and concentrated their efforts to oppose grants by the Government to private parties for the use of natural resources still in public ownership. The far greater problem of checking the enormous waste now going on as a result of present methods of utilizing natural resources is almost unheeded.

While the politicans have used the conservation movement for political purposes, engineers, who better than any other class appreciate the vast importance of real conservation to the public welfare, have steadily continued to agitate the subject. The National Chamber of Commerce announces that a referendum vote is about to be taken on the question, "Shall combinations to conserve natural resources be permitted?" The taking of this vote is the result of recommendations by a committee, the chairman of which is a noted engineer and which has in its membership two scientists who may well be ranked as engineers. The committee is made up of W. L. Saunders, past-president of the American Institute of Mining Engineers, chairman; Prof. W. B. Clark, State Geologist of Maryland; John H. Fahey, former president of the National Chamber of Commerce; Charles F. Keith, president of the Southern Pine Lumber Association; and Dr. Charles R. Van Hise, president of the University of Wisconsin.

The recommendation of this committee is that in industries which involve primary natural resources, where cooperative agreements will tend to conserve these resources, to lessen accidents and to promote the public interest, Congress should pass legislation permitting such agreements to be made without infringement of the Sherman law. The committee bases this recommendation on its studies of lumber, coal, oil and ore production.

What the committee points out has been in fact well known to engineers for a considerable time. In coal production, for example, the late Joseph A. Holmes, when head of the Bureau of Mines, pointed out that the strenuous competition and low price at which coal was produced made it impossible for the coal operators in many parts of the country to take out the maximum amount of coal from the seams that they worked. In order to maintain their place in the competitive struggle and keep out of bankruptcy they were practically obliged to take out the most easily mined part of the seam and leave the rest in the ground, to be forever unavailable for the use of humanity.

Practically the same thing has been going on in the lumber industry, as has been repeatedly pointed out by Federal experts in the Forest Service. The intense competition in the lumber business has forced lumbermen to cut from their lands the best timber that can be most readily marketed, leaving the slightly inferior qualities to decay in the forest and furnish a readily available fuel for forest fires.

It is in petroleum and natural-gas production, however, that the most criminal waste is going on, as it has been going on ever since the industry began, notwithstanding the wide public attention called to this waste at the Conservation Congress of eight years ago and notwithstanding repeated demonstrations of the need of effective measures to prevent waste.

At the recent American Mining Congress at Chicago a paper was read by Max W. Ball, of the United States Bureau of Mines, showing that at the present rate of consumption of petroleum the entire petroleum resources of the United States will be exhausted in approximately 30 years. The following extract from Mr. Ball's paper indicates something of the criminal wastefulness with which the natural resources in petroleum and natural gas are being exploited:

> Are we practicing conservation? Within the last few weeks I have seen millions of cubic feet of natural gas wasting into the air—gas so rich in gasoline that it dripped from the trees like an April shower. I have seen wells capable of yielding 40,000,000 cu.ft. of gas each being deliberately drowned out by pumping water into the gas sands. Reckless drilling, defective casing, careless plugging are flooding great areas with water and losing forever enormous

quantities of oil. It has been testified before the Corporation Commission of Oklahoma that ordinary methods leave from 25 to 85% of the oil in the ground, and this estimate is concurred in by careful engineers and practical oil men.

Nor are these underground losses the only ones. When the oil is brought to the surface before transportation and market are ready for it, it must go into storage. Indeed, in many fields oil has been produced before storage was available, and millions of gallons have gone down the streams or seeped away from earthen reservoirs. Even when the best steel tankage has been provided, evaporation losses still go on. Cushing crude stored in steel tanks for a few months lost approximately a fifth of its gasoline content. The State Mineralogist's office of California has estimated that even with the heavy oils of that state the loss by evaporation represents perhaps 25% of the total value of the production at the well. An official of one of the largest companies in the Midcontinent field recently told me that last year fire destroyed 6% of his company' production.

Just consider these examples; 25 to 85% left underground; 20 to 50% of the value of oil produced lost through evaporation in storage; 6% of stored oil lost by fire! These losses are staggering and are not exceptional! What a small percentage of this wonderful natural resource is saved to run your machine or to deliver goods at your door or to plow the fields from which your food must come!

If we feel these losses in the high prices of the present day, how much more will we feel them five, ten, twenty or thirty years from now? Is it not time we considered them seriously and tried to determine upon some remedy?

Mr. Ball further shows how in the rush to develop a new oil field and the mad competition between the different drillers the natural gas that precedes the oil is frequently allowed to waste itself entirely and the oil deposits are tapped with such haste and carelessness that water often invades the field and drowns out the oil when but a small proportion of that available has been drawn off.

In hearings before the Senate Committee on Public Lands, Jan. 12, 1915, it was shown that the companies which exploited the famous Glenn pool of Oklahoma spent $11,260,000 in drilling wells, when if the whole pool had been exploited by one producer who would have handled the work properly, all the oil could have been obtained for $3,177,000.

Mr. Ball urges that to furnish at least a partial remedy for the appalling waste now going on, the laws should be so amended that oil lands will be divided up into larger tracts, so that producers will not be under the same necessity as now to rush the work of draining off the oil at a sacrifice of all other considerations. Mr. Ball concludes his paper as follows:

If you would prevent waste of oil and natural gas, if you would do away with careless drilling methods, excessive production charges and storage losses, if you would insure the production of the maximum amount of oil at the minimum cost, if you would help to maintain a reasonable price for petroleum and its products in the years to come, then do your part in creating a public sentiment in favor of adequate acreage.

Mr. Ball's recommendations illustrate well the crying need of a better Federal mining law to govern the titles to mineral deposits. To show the active interest that engineers are taking in this aspect of the conservation movement, it may be noted that the Mining and Metallurgical Society of America has just completed a letter ballot of its membership on 33 questions in connection with proposed revision of the Federal mining law. In addition, it has submitted the same questions to a number of other organizations in the mining industry where a similar ballot could be taken.

These illustrations indicate that some engineers, at least, are endeavoring to do their duty in informing public opinion and making it effective toward bringing about intelligent legislation in the public interest. Surely there was never a time within the memory of men now living when the need was more obvious of utilizing without waste the natural resources that furnish the materials necessary for life. It may be hopeless to expect very much remedial legislation at the present short session of Congress, but the work of indicating the direction that legislation should take in order to protect the public interest ought eventually to be effective.

Letters to the Editor

Should Engineers Take Part in Politics?

Sir—Certainly an engineer should take part in politics, for the reason that every loyal citizen of a republic is in duty bound to do his part toward making an efficient government. If there exists a "polluting influence of politics and politicians," it is due to the supineness of honest, decent and intelligent men, who draw their skirts away from the political cesspools in self-centered righteousness and let the evil grow to the satisfaction of ward heelers.

Many professional men of the highest standing in law, medicine and even the ministry have entered political work to the civic improvement of their community and the honor of their profession, and without ceasing to be a lawyer, a doctor or a minister. Engineers, as a class, have not, and this neglect has not added recognition or prestige to their profession.

When we consider the immense portion of the money of taxation that is expended for public engineering work, for roads, bridges, water-supply, sewerage, canals, lighting, the regulation of rivers and the reclamation of swamps and arid wastes, it is *not* to the credit of engineers that so few are sitting as members of councils, as municipal, state and national representatives to formulate policies and procedure for the government in public work. The engineer has been content to serve only as a hired man. Let us get off the pedestal of aloofness and take our part as American citizens. LEROY K. SHERMAN.

Chicago, Ill., Nov. 27, 1916.

Sir—The reply to the important question, "Should (American) Engineers Take Part in Politics?" raised on page 1001 of your issue of Nov. 23, might be taken from the different articles and even advertisements in that same number of *Engineering News*, thus incidentally proving what a wealth of thought can be abstracted even from an engineering periodical—provided it is a good one.

I am sorry indeed to read that a few mere appeals to join some others in such an important and infrequent

matter as the election of a President of the mightiest of republics, if not of nations, shocked Mr. Dabney's professional sensibilities so considerably. He certainly never was a member of any of the democratic engineering societies of Europe. If he had been, he would have succumbed to heart failure before now, for even such renowned and powerful organizations as the Verein Deutscher Ingenieure have been guilty—very guilty. If I rightly remember, this society wanted to qualify young engineers by means of examinations to wrest from the public service those branches that were better intrusted to competent engineers than to incompetent lawyers.

But there are higher things than political jobs—than mere loaves and fishes. The circumstances of the entire engineering world should be such that its members can attain the highest. They should be enabled to devote their talents to the welfare of the commonwealth. If engineers should throw themselves into that "low political scramble," they should go in to make themselves felt and the more respected, which the American engineer, compared with those abroad, is not. Once having his rightful place in the community, he will find opportunity for his reasoning powers to be of greater benefit to the American people than is now the case.

The American masses are of a materialistic turn; they never will respect where there is not prosperity, and the American engineer is not prosperous. The body of American engineers is not constituted by that very small percentage of them who have offices. Most emphatically not. And that small percentage is not qualified to judge whether the greatest part by far—the engineer wage earners—should mix in the fight or not.

As I said, that number of *Engineering News* was full of information bearing on the subject. Glance through the list of men without positions, the jobless. Again, page 1010 tells a striking story of what the navy offers to the cream of America's engineers, men of about 40 with a highly successful past—$10 a day. It is unnecessary to enlarge on this. It states plainly that engineering in America is a disillusion financially and, as America is materialistic, socially, as well.

But there is hope. Mr. Fleming in the same number and in previous issues has proved to be a champion of the cause. He has demonstrated the fitness of the engineer to take part in public affairs, and he has discussed the engineer as a writer of fiction. It was the gladdest note I ever read in any American professional publication.

It brought visions of bygone days in Europe, in Australia, even in the lost corners of semi-barbaric Asia, where there was at any rate time to read, to relax the mind. What does the American engineer know of literature or art or of music? Back bent over a table, or from dawn to dusk in the dirt, is his part in both daily work and recreation. For concerts he has no money, and of art he sees glimpses only amid a holiday crowd.

Should American engineers join in politics? Yes, most emphatically, yes. Not for the loaves and fishes, but because they, with their intellectual powers, with the invariably accompanying sense of fairness and right, should wrest the affairs of state out of the hands of grafting politicians, to elevate themselves and with them the entire nation. Our profession, in which there is no give and take, has shaped the engineer into the honest man he is. His contact with men, his thorough education, have predestined him to be an admirable leader; and if it were only as a means to the end, the American engineer should mix in politics—and not for a presidential election only.

JAN SPAANDER,
(A neutral and appreciative guest of America).

Brooklyn, N. Y., Nov. 27, 1916.

[Mr. Spaander's arraignment of American engineers is rather severe as applying to them as a class or profession, for it would apply with equal potency to most other Americans. Moreover, if his acquaintance with the lives of many of our best engineers had been broader, he would know that the love of literature, art and music is not so rare by any means.

It is unjust to say that engineers have been nonentities in American civil government. Many an engineer in the same quiet, unassuming and unpretentious way that he has accomplished great objects in engineering, accomplishes an equal amount of good for the city, state and nation. The unwritten, little known part of the biographies of these men often shows a most unselfish devotion to the public welfare. And while it is true that many reforms require a more militant spirit, we should not overlook this other means of serving the public.—Editor.]

Sir—I note in *Engineering News* of Nov. 23, p. 1001, a letter from my good friend, Maj. T. G. Dabney, deploring the active participation in national politics of civil engineers—members of the American Society of Civil Engineers.

I certainly share his feeling that our honored organization, as such, should keep out of politics. But I also feel that we should, as individuals, have as patriotic a desire as any other citizens of the Republic to promote what each conscientiously believes to be for the greatest good of the land of his birth; and that all engineers who think alike should combine to bring about those results which they believe will conduce to the greatest good.

When we become engineers, we do not cease to be citizens; and the duties of citizenship should be discharged as conscientiously as any trusteeship that we hold as professional men.

The question arises, Will the participation in politics of men whose standards of honor are as high as those embraced by our profession tend to lower those standards, or will they help to raise the grade of political morals? I believe in the latter alternative.

Major Dabney mentions two appeals made to him by prominent engineers, holding opposite views as to the presidential candidates. I was the Chicago member, making my appeal for President Wilson, but asking no contribution to the expenses of the campaign. I sent out a large number of personal appeals for the man of my choice and was much gratified by the responses. Some men whom I felt sure were rock-ribbed Republicans replied that they would vote for Mr. Wilson.

I believe that engineers should make themselves felt in civil life as well as in civil engineering. I want to say further that in our association with one another our political leanings should make no difference in our professional brotherhood. In a long professional life I have never been influenced in employing assistants by their political faith. All that I have wanted to know about them has been their ability to do the work and their conscientiousness in its discharge.

ISHAM RANDOLPH.

Chicago, Ill., Dec. 1, 1916.

Detecting Initial Stress in Bronze

Sir—Referring to the editorial in the issue of *Engineering News* for Nov. 23, headed "More Evidence of Unreliability of the Stronger Bronzes," I think that a short statement in regard to what was actually found as the cause for the difficulty with the manganese-bronze rolled material on the Catskill Aqueduct will be of service in making clear to engineers that, *with proper inspection and under proper specifications*, rolled manganese bronze would appear to be an entirely satisfactory material, in places where its resistance to corrosion and its strength are desirable qualities.

Alfred D. Flinn, Deputy Chief Engineer of the Catskill Aqueduct Board, presented a paper to the American Institute of Metals at its meeting in September, 1915 (published in the *Proceedings* of the society), in which he describes in detail the difficulties that had been experienced. This paper is very complete and instructive. Prior to this time, the matter had been referred to in *Engineering News*, as you state, and in some of the trade papers.

The same troubles have been experienced in other places with the same material, but in the case of the Catskill Aqueduct, conditions were so serious, and the amount of money involved was so great, that especial attention was directed to the difficulty.

At the same meeting of the American Institute of Metals referred to, a paper was read by P. D. Merica and R. W. Woodward, of the United States Bureau of Standards, which gives a very complete account of the investigation which the Bureau made in this connection, and in which are given a number of valuable references. The reference to which attention should be especially called is the paper by Prof. E. Heyn, of the Royal Technical Institute of Charlottenburg, presented to the Institute of Metals as the May lecture before that body in 1914. This is a very complete, theoretical and practical exposition of the subject of internal strains in cold worked material. The subject was investigated by Dr. Heyn on account of the cracking of steam turbine blades made of nickel steel containing about 25% of nickel. Strain diagrams were given of this material and of various nonferrous alloys. This paper is the basis of the work done by the Bureau of Standards here referred to.

The difficulties that arose in the case of the Catskill Aqueduct material are quite common in other brasses and bronzes that are subjected to cold work such as drawing, stamping, etc. For instance, in cartridge cases made of brass, difficulty is frequently experienced by the material cracking after it has been in storage for a while; and for this reason, the phenomenon is usually referred to as "season cracking." This cracking has been known for many years, and has been ascribed to many causes; but since the paper by Professor Heyn appeared, and since the investigation by the Bureau of Standards has been made, it would appear perfectly clear that the real cause is an excessive initial strain in the rolled material due to the rolling; or in the case of drawn or stamped material, to the cold work and consequent local strains set up by the method of manufacture.

It may be of interest to note that these initial stresses, according to Heyn, were as high as 22,400 lb. per sq.in., these measurements being taken five days after the bar had left the drawing die. Two years afterward, this strain had increased to 26,600 lb. per sq.in. These figures were the maximum tensions found by Heyn's method in a bar containing 57.8% copper, 40.8% zinc, and 1.35% lead. The tests of the Bureau of Standards show maximum tension stresses in material that had not been used of 94,000 lb. per sq.in. Of course, this is exceptional, although there were a number of instances where the stress was from 17,000 to 34,000 lb. per sq.in. It is evident that such initial stresses in the material inevitably resulted in failure, particularly when additional stresses were introduced in service.

It is well known that annealing will relieve internal strains if properly conducted, and the results of Professor Heyn's tests show this effect very markedly. For instance, the bar above referred to, when heated for three hours at 160° C., reduced the maximum tensile stress to about 15,000 lb. per sq.in.; while heating it for three hours at 230° C. reduced the initial stress to 3,500 lb. per sq.in.

The tests of the Bureau of Standards confirm this, and show that a temperature of 400° C., for a period of one hour, reduces the initial stresses to a safe limit without altering the physical qualities.

It therefore appears entirely possible, as stated before, to use manganese bronze or other high-strength brasses, provided proper methods of manufacture are used, and checked by proper inspection.

Inasmuch as Heyn's method of determining these internal stresses is rather complicated, and more suitable for laboratory purposes than for ordinary inspections, although it gives accurate results, the writer devised a method which is quite accurate, although not so accurate as Heyn's method, and which would appear to be suitable for ordinary inspection. It consists in cutting from a bar of the material a longitudinal strip of segmental section, the included angle at the center being 30°. If there be an initial strain in the material, this strip will not be straight as it was originally, but more or less curved. It is quite easy to measure the deflection of the curve, and knowing the length, it is quite easy to figure the approximate initial strain.

This method was submitted to the Bureau of Standards, who tested it and found that the facts are as above stated. The results obtained are given in the following table as found in three different cases:

Change in Strain at Outside Fiber, Author's Method	Maximum Strain at Outside, Heyn's Method
+30,000	+34,000
—4,720	—6,000
+41,000	+94,000

With regard to the accuracy of the method, it should not be forgotten that the bending of the strip does not entirely relieve the strain, and that the method is therefore only approximate; but it appears to afford a good idea of the magnitude of the strains, and therefore I feel that it is of value for inspection purposes.

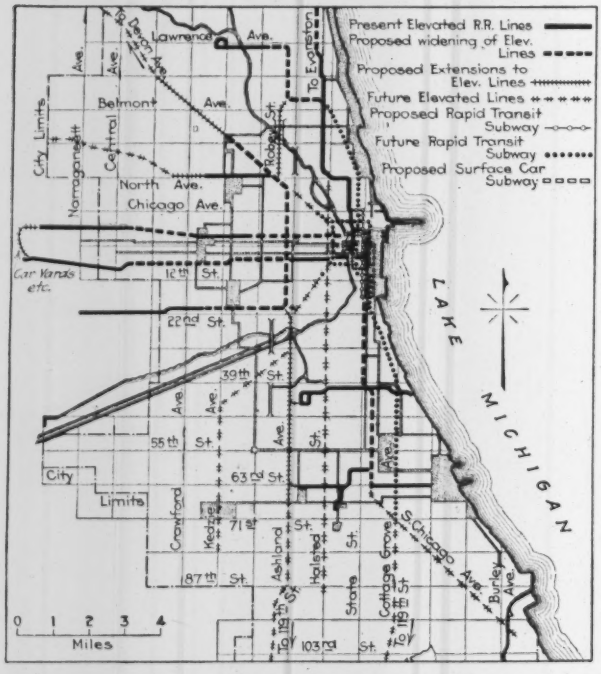
In conclusion, I feel that such a magnificent metal as manganese bronze, which is so suitable for many purposes, should not be handicapped in its application by the idea that it is inherently, and for some mysterious reason, defective; and I believe that with proper inspection, and under proper specifications, the bad name that it has acquired in many quarters will be changed, and its use will increase as it should. S. W. MILLER.

Rochester, N. Y., Nov. 25, 1916.

The Future Rapid Transit System of Chicago

The further development of the passenger railway lines of Chicago, planned by the Chicago Transit Commission, was briefly described in the last issue of *Engineering News*. The accompanying map shows the location of the principal lines which it is planned to enlarge and extend.

As shown by the map, the principal feature of the development the Commission has planned is the provision of rapid transit by four-track elevated lines instead of by subways. The Commission points out that the investment necessary to build an elevated railway is about one-fourth as great as that necessary to construct a subway and the traffic capacity of the two are equal. In Chicago there is no such great concentration of traffic in one direction as exists on the long narrow area of



PROJECTED RAPID TRANSIT SYSTEMS FOR CHICAGO

Manhattan Island. In Chicago the chief transit lines radiate from the central business district, and rapid transit service can be secured at the least outlay by adding additional tracks to the present elevated lines with some extension of the elevated system in outlying parts of the city. In the central business districts, however, where obstruction of streets by additional elevated tracks would be impracticable, subways are to be constructed. The difficulties in building these subways will be greater than those which have been encountered in New York or in Boston, on account of the soil conditions. With proper care, however, the Commission believes that subways can be constructed without serious damage to the buildings along the route.

In addition to the subways for the rapid transit lines in the congested district, the Commission has recommended additional subways in this district to remove the surface cars from certain crowded streets. Some rather serious difficulties in subway construction are introduced by the existing network of small tunnels in the central business district, used by the Illinois Tunnel Co. for freight distribution in small-size cars. The subways will have to pass above or below these tunnels, and the difficulties of construction are thereby considerably increased. If any further extensions of the Illinois tunnel system are made, the franchise should require the location to be such that no interference with subways for city passenger traffic can result.

The estimated outlay for the construction program which is to extend over nine years, but a considerable proportion of which will be carried out during the next three years, is $100,000,000. The enlargement necessary to provide for the city's growth over a longer period, during which it is estimated the city may reach a population of 5,000,000, will involve an eventual outlay of $260,000,000. This makes the rapid transit development of Chicago as an engineering enterprise rank among the largest now projected in the world.

In undertaking this work, Chicago has certain great advantages through the concentrated financial control of its surface railways and of its elevated lines; and further, because of the large financial interest which the city already has in the surface lines.

To finance this great enterprise will require the united strength of the municipality and the corporations. The advantage of having the entire system, surface lines, elevated lines, and subways, operated under one management, is so obvious that this recommendation of the Commission will doubtless receive general approval.

The members of the Commission, which was appointed nearly a year ago, are Bion J. Arnold, of Chicago, William Barclay Parsons and Robert Ridgway, of New York City.

Mechanical-Filter Standards

Capacity rates for water filters of the mechanical type, with special reference to filters for other than municipal purposes, formed the subject of a report of a committee of the American Society of Mechanical Engineers, submitted by George W. Fuller, chairman, at the recent annual meeting of the society.

The committee points out that there is no need of standardizing construction details, since there is a wide legitimate field for individual preference or convenience here. With the proper rate of filtration the case is far different, since this depends on the laws of nature. Associated with this rate are some other matters deserving attention.

Capacity can best be expressed in gallons per square foot of filter surface per minute. The upper surface of the bed should be used even in the case of horizontal cylindrical filters. Ample capacity to meet maximum demand should be provided. The recommended depth of filter bed is 33 in., "of which at least 24 in. is sand or similar fine material of suitable size and grade." Minimum thicknesses of 27 and 18 in. respectively are named. Bed thickness is independent of the washing devices used. On the subject of filter medium the report says:

The most desirable filter medium is a granular substance of a hard, nonporous, insoluble character, with grains substantially uniform in size and shape, the exact size and uniformity of the particles being open to some variation depending upon local conditions. If properly washed, such a filter bed will remain in efficient working condition for several years.

Bone charcoal or other porous material is sometimes of aid in the removal of iron, color, tastes or odors. But if they are used, it must be recognized that growths of bacteria in the effluent are very likely to occur, although there is no evidence to indicate that such growths include disease-producing germs.

Coming now to the main point of the report, the rate of filtration, the committee says:

"The permissible rate of filtration in any instance depends upon the character of the water to be filtered and the purpose for which the water is used. If the water is for domestic purposes, whether the filters are installed in a municipal plant or otherwise, the rate of filtration should not exceed that which has been adopted for such service by universal consent of filtration engineers. We therefore recommend that:

a. Whenever the water is to be used for domestic purposes or to secure full bacterial purification, the capacity shall be based upon a rate of filtration not to exceed 2 gal. per min. per sq.ft. of filtering area, and a coagulant must be used.

b. Where a lesser degree of purification is required, either because the water is not to be used for domestic consumption or because the water to be filtered is already sufficiently free from bacteria, or where the filtered water is to be effectively sterilized, a higher rate of filtration may be used, but not to exceed 3 gal. per sq.ft. per min.

Double or series filtration, through material of the same character, is not good practice. Better results are secured by operating the filters in parallel, thus giving a lower rate. For some waters it may be advisable to use a secondary filter of fine material to remove fine suspended matters that pass the primary filter. Where iron, color, odor or taste is to be removed, a primary sand filter and a secondary filter of bone charcoal, or some other porous material may be employed, provided there is no objection to an increase in harmless water bacteria through growth in the porous medium. But in any case the rates for double filtration should not exceed those for single "unless warranted by the results of experiments" or advised by "a competent filtration engineer."

It should be understood that, with the rapid rates approved in the report, proper coagulation of the raw water is imperative, and in the case of very turbid water preliminary sedimentation must also be considered.

It has been found that sterilizing the filters with steam is of temporary advantage only, and sometimes results in the growth of water bacteria in the filter. Disinfection can best be secured by treating the filtered water by liquid chlorine, hypochlorite of lime or ultra-violet rays.

Detroit Sewer Construction Severely Criticized*

Like many municipalities the inspectors in the Detroit sewer department are frequently political ward workers with or without qualifications. With a compensation of $4 per day, irregular time, many receive more than they possibly could elsewhere. A yearly salary of $1,000 to $1,200, and the position made a stepping stone to promotion are some of the recommendations. At present the inspectors, as a body, are not competent, the inspection service is not efficient, and good contract work is secured by chance.

The methods of undertaking sewer work by day labor are off-hand and informal. No estimate or bid of the probable cost of this work is made by the Sewer Department, nor are detailed cost data of work done. The general superintendent of the department examines the city engineer's estimates and all the contractors' bids submitted, and with this information and his own experience concludes whether or not he can do the work for less than the lowest bid. It is recommended that the superintendent submit sealed bids or estimates based on carefully kept cost data of past work.

The construction of storm sewers by the Sewer Department is usually done without stakes for either line or grade, nor is the completed sewer surveyed, nor is a record plan prepared or filed. The so-called "sight-arm" method of giving grades is in vogue. Long stretches of storm sewers have been constructed to connect with only one or two inlets. A more careful layout of street grades would reduce the work of storm sewer construction.

Seldom after sewers are designed and constructed is attention paid to their operation for the purpose of checking the accuracy of the methods of design. It is suggested that a careful study be made of the operation of existing sewers in connection with the compilation of rainfall records extending over a period of years, and that from these data the present method of design be checked by the so-called "rational method."

In general, the quality of construction work inspected was found to be poor and not in accordance with the specifications—with one exception. The pipe laying inspected was extremely poor. No attempt was made to build the sewers to a true line and there was only a rough attempt to obtain a true grade. Bell holes for the pipe were not excavated, and the pipe was improperly bedded. No mortar was placed at the bottom of the joints and very little in the joint below the springing line of the pipe. The only operation which seemed to be well done was the backfilling in open cuts.

In the performance of routine work over a period of years, the whole conduct of sewer construction has apparently slipped into a rut. The reasons for present conditions may be traced to two sources: Laxity of supervision and political influence in the selection of inspectors.

Little attention seems to be given to the quality of materials used on the work. The specifications are none too explicit as to terms under which various materials will be acceptable to the city, and laxity in inspection of materials is to be expected. Occasional, if not regular, testings of all materials accompanied by explanations to inspectors of results found would have a beneficial effect in improving not only the quality of materials used, but in raising the entire standard of construction work.

The specifications contain numerous "requirements" to which little or no attention is paid. Many important paragraphs can be analyzed and numerous requirements found which are not enforced. The contractor should be allowed to bid on specifications which mean what they read. Under the present practice in the construction of sewers it is difficult to see how an outside contractor can bid intelligently. Either the contractor must assume that the specifications will be ridgidly enforced and bid accordingly, or in order to compete with contractors who understand that various clauses will not be enforced, he must anticipate non-enforcement of the specifications. A superficial examination of published bids does not indicate, however, that the cost of sewers is excessive, were first-class work obtained.

*From a report on the sewer construction work of the Detroit Department of Public Works, prepared by the Detroit Bureau of Governmental Research, of which H. S. Morse, formerly Engineer of Sewers of Cincinnati, is engineer. The paragraphs given are extracts from the report.

News of the Engineering World

Warehouses on Terminal Piers for Camden, N. J.

In a report to the Board of Harbor Commissioners of Camden, N. J., B. F. Cresson, Chief Engineer of New Jersey State Board of Commerce and Navigation advises the construction at that port of an innovation in American harbor practice; that is, the placing of large storage warehouses upon terminal piers, so that ships, trucks and railway cars can load directly one to the other or each to the warehouse.

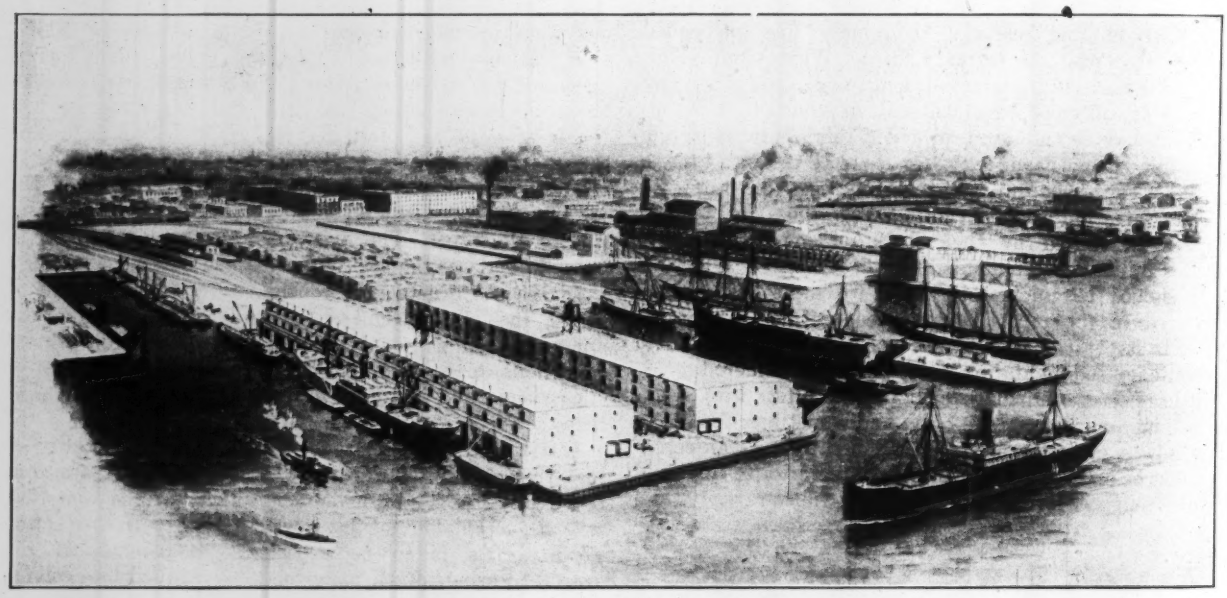
The report, dated Dec. 4, 1916, recommends the development of the port of Camden, directly across the Delaware River from Philadelphia, by the construction at a cost of approximately $1,000,000 of two new piers, on one of which, shown at the left in the accompanying view, will be erected the warehouses, which are described in the report as follows:

The pier will be a wide solid filled structure with a timber bulkhead and a platform constructed outshore of the bulkhead to provide deep water wharfage. It will provide dockage for a 600-ft. ship on one side and a 480-ft. ship on the other. It will be 326 ft. wide over all and will be divided longitudinally into two separate operating parts, each with the same facilities except the driveway in the middle.

There will be a three-story shed along the north and south sides of this pier. The lower floor will have a vertical clearance of about 22 ft.; this will be for the protection and handling of cargo in transit. The second and third floors, each of which is stepped back 5 ft. on the water-side to provide a landing and working platform for cargo, will have a vertical clearance of about 12 ft.

The floor of the lower level will be 100 ft. wide back from the string-piece and there will be two railroad tracks in a pit immediately adjoining the floor and within the building. The elevation of the pier floor will be the same as that of the floor of the car and this will facilitate the handling of freight between the pier deck and the cars. Immediately to the rear of the shed will be a platform 10 ft. wide at the elevation of the car floor, and adjoining this will be a street or roadway 60 ft. in width. The second floor will have a width of 111 ft. exclusive of the landing platform, and the third floor will have a width of 106 ft. exclusive of the landing platform. The shed on the northerly side will have a length of 560 ft. and on the southerly side will have a length of 480 ft.

With such an installation trucks may drive on to the lower deck of the pier where they may deliver or receive cargo to or from ships. Cargo which is coming from ships to railroad cars may be trucked directly across the floor of the pier and into the body of the cars at the same level as the pier floor, and a similar process for cargo going from railroad cars into ships. Cargo that is received from ships for storage or warehousing will be unloaded directly on to the platforms of the second or third floors to the warehouses by means of the ship's tackle and portable electric winches and cargo hoists. Cargo from the warehouses or storage houses going into ships will be unloaded from the platforms along the edge of the pier into the ships in similar manner. Cargo going from the warehouses to railroad cars will be lowered from the doors of the warehouses on the street side on to narrow platforms to the rear of the sheds and from these platforms into the body of the railroad cars on the level of the platforms. Cargo going from the warehouses into trucks will be lowered in a similar manner to the platform and directly into the trucks.



PROPOSED DEVELOPMENT ON DELAWARE RIVER AT CAMDEN, N. J.

Quick Work Handicaps Bidder on Cleveland Filter Repair

Bids were received on Dec. 6, 1916, for the reconstruction of the clearwater basin in the Cleveland Division Ave. filtration plant which, as detailed in *Engineering News*, Dec. 7, 1916, p. 1099, is showing such serious settlement. The repair work comprises a complete relining of the basin by the construction of what amounts to an entirely new structure inside of the old. Bids were asked on itemized quantities and in addition an exact time limit had to be specified for two particular parts of the work, with a penalty of $250 per day for

overtime on each section. In comparing bids the collected totals were added to an amount found by multiplying the mean number of days specified for the two parts of the work by a fixed sum of $500 per day.

Three bids were received, as follows: F. W. Mark Construction Co., Inc., Cleveland, Ohio, $331,708.50 plus $55,000 (110 average days) or $386,708.50 for a comparative total; John F. Casey Co., Pittsburgh, Penn., $328,317 plus $91,000 (182 average days) or $419,317; The Masters & Mullen Construction Co., Cleveland, Ohio, $330,457.15 plus $110,000 (220 average days) or $440,457.15.

It will be seen that the basic bids are remarkably close. Each bidder was asked to outline the program of his work, which must be prosecuted during the coming winter, under what is usually, in Cleveland, severe weather conditions. After considering the different programs the water commissioner recommended the letting of the contract to the J. F. Casey Co., who had the lowest bid but whose time limit was higher than that of the Mark company. In presenting this recommendation to the Board of Control, the commissioner said that the time specified by the Mark company seemed so short that it was to be feared that no matter how honest their intentions they would constantly be under pressure to put more effort into speed than into thoroughness. Furthermore the program of the Casey company seemed more possible of execution. The contract was thereupon awarded to the J. F. Casey Co.

Chicago Sewage Dilution Hit

Two opinions on the Chicago sewage-disposal system have been given out during the past week. They were published on the same day, and both are strongly adverse to the present policy of disposal by dilution. An extract from the annual report of the Chief of Engineers, United States Army (published in the local press), states the case as follows:

> Modern expert opinion is to the effect that the disposal of sewage by dilution in the manner practiced by the Chicago sanitary district is neither economical, efficient nor in keeping with the public spirit that should direct undertakings of this kind. The present practice is to apply some form of treatment to the sewage which shall remove its more offensive characteristics before it is released and permitted to flow past the waterfronts of near-by communities.

The report states that the Sanitary District of Chicago is drawing from Lake Michigan a much larger quantity of water than the 4,167 cu.ft. per sec. permitted by the Secretary of War, the average flow through the Chicago River to the drainage canal since 1910 being over 7,000 cu.ft. per sec. This represents a daily average of nearly 600,000,000 cu.ft. of water drawn from the lake, which is about equal to the entire low-water flow of the Mississippi River at St. Paul.

The report further states that the continuous withdrawal of such a volume of water will result in permanently lowering the water level about 5 in. in Lake Michigan and Lake Huron and nearly as much in Lake Erie. This would seriously affect river and harbor works as well as navigation and lake commerce. The International Waterway Commission has estimated that a 6-in. lowering of the water level would reduce the loading of large lake vessels by 300 to 550 tons, and thus cause an annual loss of about $1,500,000. Furthermore, the state authorities of Illinois are said to contemplate a still greater diversion, 10,000 cu.ft. per sec. or more.

The second adverse opinion, strange to say, comes from within the Sanitary District of Chicago. The new president of the district, Charles H. Sergel, who was elected by popular vote in November, in his inaugural address on Dec. 5 came out squarely in opposition to the dilution system, although this system has been the practice and policy of the Sanitary District since its earliest days. He also predicted restriction of the supply of water from the lake by the United States Government. Mr. Sergel has not been connected with the Sanitary District until now, and this expression of his attitude has met with strong objection on the part of the Board of Trustees, the principal argument being the great expense involved in any other system. The following is a quotation from Mr. Sergel's address:

> The most important work of the sanitary board in the next few years is the putting into active operation of modern methods of sewage treatment to supplement the dilution method of disposal now in use, so that eventually our rivers—the Chicago, the Calumet and the Des Plaines—will no longer be open sewers. Our great metropolis, which should march in the van, has been lagging in the rear.
>
> The work of experimentation that the sanitary board has been carrying on for many years must have supplied enough facts and principles and methods. If not, other investigations have. Let us now put these principles into operation by constructing treatment plants, and thus rescue our rivers from sewerdom. We then will be in no danger of having the entire sewage system paralyzed by the United States Government's reducing the supply of water from the lake, for even the minimum supply will be sufficient.

Free Consulting Engineering Services in Minnesota

It is reported that the regents of the University of Minnesota, in their budget for the next two years just formulated for submission to the legislature, have provided for the employment of a consulting civil engineer in the University Extension Department, whose services would be free to Minnesota cities and towns. This appears to be in line with a resolution adopted on Oct. 19, 1916, by the Minnesota League of Municipalities, as follows:

> We, your special committee appointed to consider the question of having an engineer in connection with the State University Extension Department who will be at the service of the members of the league in an advisory capacity, do recommend that steps be taken to have such an engineer of maturity and wide experience in municipal work added to the faculty. Respectfully submitted, William Ries, Shakopee; P. A. Hustad, Benson; Frank Lonergan, White Bear; Frank A. Bowman, Gilbert.

The names and addresses attached to the resolution seem to indicate that the demand for free consulting services comes from the smaller communities of Minnesota.

St. Louis May Spend $8,000,000 To Improve City Plan

Prevention of floods and of stream pollution, together with a remarkable opportunity for industrial development and a chance at the same time to provide a residential area and an interesting and useful circuit driveway, are the leading recommendations in a report entitled "River Des Peres Plan," just issued by the City Plan Commission of St. Louis, Mo. The reason for choosing this area for consideration in advance of making a plan for the whole city was in part the floods that occurred in the River Des Peres Valley on Aug. 20, 1915. Another reason was the unusual opportunity afforded for planning well in advance the utilization of an area instead of waiting until hap-

hazard developments made a logical plan almost impossible. It may be mentioned in passing that the City Plan Commission is composed of nine members, with James C. Jones as Chairman, Walter B. Stevens as Secretary, and Harland Bartholomew, Engineer. Five city officials are ex-officio members of the commission, including E. R. Kinsey, President of the Board of Public Service, and Charles M. Talbert, Director of Streets and Sewers.

The four elements of the improvements recommended and their estimated cost are as follows:

Open channel, closed sewer and all other related construction	$5,815,450
Double-track industrial railroad, complete	526,000
Driveway from Kingshighway, Southwest, to McCausland Ave. and Manchester	1,277,668
Ivanhoe Ave.—McCausland viaduct (city's share)	400,000
Total	$8,019,118

The commission proposes that the entire cost of this project be made a charge upon the city, to be met by a 20-yr. bond issue. It advises that an item for this amount and purpose be included in the referendum on municipal bond issues likely to be held in April, 1917.

The main drainage canal contemplated would be an open channel 160 to 180 ft. wide and 18 ft. deep, built of reinforced concrete, extending from the Mississippi River to the several forks of the River Des Peres in Maplewood. This channel would carry both sewage and storm water. From its upper end to Macklind Ave. there would be a channel about 80 ft. wide and 16 ft. deep for surface water, beneath which there would be a sewer. From Macklind Ave. to Union Ave. in Forest Park there would be a double-section reinforced-concrete sewer, each section being 27 to 30 ft. wide by about 20 ft. high. From the upper end of this section to the city limits in Hodiamont, there would be a single reinforced-concrete conduit, about 30 ft. wide by 23 ft. high. Besides the channel and large conduits various sewers would be built and some existing sewers rebuilt.

The excavated material from the channel would be used for the proposed industrial railway, parallel thereto. Well toward a thousand acres of otherwise largely unusable land would be made available for industrial purposes.

Mechanical Engineers' Meeting Breaks a Record

At the 37th annual meeting of the American Society of Mechanical Engineers, held last week at the Engineering Societies' Building in New York City, the total registration was 1,786, the largest on record. The number of members registered was 924 and the number of guests, 862. In 1914 the registration at the annual meeting was 1,367.

At the opening session on Tuesday evening, the retiring president, Dr. D. S. Jacobus, gave the annual presidential address, taking as his subject "Education in Engineering." Speaking from twenty years' experience as a teacher at Stevens' Institute of Technology and over ten years' later experience in engineering work, Dr. Jacobus referred to the list of essential factors desirable in young engineers prepared by the Carnegie Foundation in its investigation of engineering education. He then described other qualities which he believed deserved special attention as follows: (1) Taking a personal interest in one's work; (2) amenability to discipline; (3) perseverance under adverse circumstances; (4) cheerfulness and amity—the human side.

Dr. Jacobus declared that the present entrance requirements to engineering schools do not accurately gage the ability of an applicant and he believed it a mistake to make the entrance requirements to an engineering college too high. He urged that some of the time in college now spent in specializing should be devoted to more thorough teaching of the fundamental branches. At the conclusion of the address, Dr. Jacobus introduced the newly-elected President, Dr. Ira N. Hollis, President of Worcester Polytechnic Institute. In a brief speech Dr. Hollis emphasized the idea that the efforts of the society should be directed toward rendering service to the nation.

At the annual business session on Wednesday morning, the annual reports of the Council and standing committees were presented. The total membership of the Society is now 7,244, a net gain of 667 during the year. The total is made up of 4,585 members, 1,553 juniors, and the balance in other grades. There are also 841 students in engineering colleges affiliated with the Society through membership in student branches. The Society is in a flourishing financial condition. It had a gross income last year of $167,141, and its expenses were $143,023. The last indebtedness on the Society's share in the purchase of the Engineering Building site was paid on July 1, and the Society's balance sheet shows total assets of $720,672, the chief item of which is the Society's one-third interest in the Engineering Societies' Building and the land on which it stands.

The prize for the best paper submitted by a junior was awarded to L. B. McMillan, Instructor in Steam and Gas Engineering, University of Wisconsin, for his paper entitled "The Heat Insulating Properties of Commercial Steam Pipe Coverings." Honorable mention was awarded to Victor J. Azbe, of St. Louis, and Herbert B. Reynolds, of New York City.

The report of the committee on the standardization of filters used to purify water for industrial purposes was presented by the Chairman, George W. Fuller. An abstract of the committee's report is printed elsewhere in this issue. At the close of the business session, the reading and discussion of technical papers was taken up and two simultaneous sessions were held, one considering various papers on steam boilers, the other proposed code of safety standards for cranes.

During the noon hour, exercises were held in honor of the memory of the late John E. Sweet, of Syracuse, a past-president and honorary member and the founder of the Society. Reminiscences concerning Professor Sweet were given by Worcester R. Warner, Capt. Robt. W. Hunt, and others. In the afternoon four simultaneous sessions were held, one devoted to power plant engineering, one to textile engineering, one to machine shop practice, and one to industrial management. In the evening a smoker was held at which the feature of attraction was an address by Frank B. Gilbreth recounting his experiences "somewhere in Germany" during the war.

The principal features on Thursday were two sessions on valuation, with special reference to methods of valuation for industrial plants. A session was also held of the gas power section. The principal social event of the meeting was the annual reunion held on Thursday evening. Instead of resorting to some of the large hotels, as has been the custom in previous years, involving a heavy expense, the reunion was held in the Engineering Societies' Building. The fifth floor of the Engineering

Societies' Building has been altered and redecorated to make it attractive for social gatherings, and it was used this week not only for the Thursday evening reunion, but for the reception on Tuesday evening and for luncheons Wednesday and Thursday noon. On Friday, the closing day, three simultaneous sessions were held. In the auditorium the development of naval construction in the United States was shown; and the other meetings were devoted to steam boilers and to railway engineering.

Highway Improvement in the Northwestern States

The definite and practical aspects of highway improvement and highway development were featured strongly in the third annual meeting of the Northwestern Road Congress, held at the Sherman Hotel, Chicago, on Dec. 7 and 8. The attendance was good, and the program was excellent, and as it had a relatively short list of papers, it was followed out pretty closely, most of the papers being presented and discussed in the time available. In addition, the papers were mainly of commendable brevity.

These papers covered the ground as follows: Earth roads, John H. Mullen (Minnesota); oiled earth roads, B. H. Piepmeier (Illinois State Highway Department); gravel roads, J. T. Donaghey (Wisconsin); macadam roads, H. G. Shirley (State Engineer of Maryland); concrete roads, A. N. Johnson (consulting engineer for the Portland Cement Association), and brick roads, E. B. Schmidt (Indiana). All these papers laid stress upon the importance of maintenance from an economic as well as a traffic point of view. Further, there was a paper on the maintenance problem of state roads, by W. D. Uhler, Chief Engineer of the Pennsylvania Highway Commission.

The gravel road construction employed by Mr. Donaghy is of the two-course type, dressed with a harrow and grader and well rolled. Clay may be added if necessary, care being taken that the quantity is only sufficient to act as a binder and not enough to make a muddy road in wet weather. Oiling may be done as required. He considered this as the best of the medium-priced roads, and figured the comparative cost of gravel and concrete as follows, these figures including maintenance and interest charges:

	Cost per Sq. Yd. at the End of—		
	5 Years	10 Years	15 Years
Concrete road	$1.65	$2.11	$2.71
Gravel road	.98	1.70	2.60

The macadam roads now built in Maryland are all bituminous-bound, a light oil binder being used. Mr. Shirley described the patrol system of maintenance, and expressed his opinion that maintenance work should be of such character that after several years' service the road would be better than when it was built. Investigation is made as to the tonnage carried and the depth of wear, and he urged the ton-mile as the proper basis for repair costs.

In concrete road construction, Mr. Johnson emphasized the importance of thorough consolidation of the subgrade, and careful finishing of the concrete so as to remove surplus water and get a hard and dense surface. Hand floating destroys the even contour, but the finishing may be done by a roller, a belt or a machine-float. In the discussion Mr. Kuelling (Milwaukee, Wis.) advocated increasing the width of paved road on curves, and stated that he found concrete made with large-sized aggregate (1- to 2-in. stone) showed less wear than that made with the smaller size of coarse aggregate. Another paper dealt with bridges and culverts.

Subjects of an administrative character included state and interstate road systems, the coördination of the highway programs of various states, the new law providing for participation by the United States Government, in highway development, and the education of the public in regard to the bond-issue system of paying the cost of road improvement. During the meeting there were numerous moving-picture displays illustrative of road work, and the convention closed with an illustrated lecture on the great highways of America.

Minnesota State Health Board May Be Reorganized

A reorganization of the Minnesota State Board of Health has been recommended by a commission appointed by Governor Burnquist to recommend desirable legislation concerning public health. Dean E. P. Lyon, of the university medical college, is chairman of the commission.

The present state board of health consists of eight doctors and one civil engineer. Up to one year ago the board had always consisted of doctors. Governor Hammond was requested, by the Civil Engineers Society of St. Paul, to fill the next vacancy by appointing a sanitary engineer and did so.

The commission recommends:

That membership on the board be open to men in the different walks of life instead of physicians.

That the board consist of five members instead of nine.

That the board be granted broad, general powers, instead of specifying in detail the limit of its duties and activities.

That the board be empowered to appoint a commissioner of public health, who shall be a "field general directing an army," more than an officer charged with enforcement of law.

That industrial hygiene regulations be transferred to this new board from the State Department of Labor.

That the commissioner be a man trained in sanitary science and public health administration and devote his whole time to the work and be paid a salary high enough to secure an able man.

Concrete Arches Favored for Galveston Causeway

The Board of Arbitration appointed by the various interests involved in the reconstruction of the Galveston Causeway has recommended, under date of Dec, 4, 1916, that the part of the structure washed out in the storm of August, 1915, be replaced by the concrete-arch structure submitted by the Concrete-Steel Engineering Co., with certain modifications in detail. These changes relate to additional reinforcement, extension of the pier footings and use of a richer concrete. The estimated total cost of this scheme is $1,376,000 to which must be added $140,000 for the repair of the Galveston approach. The Board considered that the concrete girder plan submitted would cost more than the authorized expenditure.

The Board of Arbitration consisted of Prof. A. N. Talbot, named by the steam railroads, Prof. G. F. Swain, named by the interurban railway and the county and Lincoln Bush, selected by the other two arbitrators. The Board of Engineers which is to decide upon the proper structure is headed by Frank Merritt, Chief Engineer of the Gulf, Carolina & Santa Fe R.R. Mr. Merritt has authorized the publication of the report of the arbitration.

Navy Wants Contractors' Advice on Contract Provisions

The Navy Department, Bureau of Yards and Docks, Washington, D. C., is arranging for a conference with a number of building trades associations, contracting companies, and other parties interested, for the purpose of discussing its General Provisions, specifications and contract requirements. The Bureau is particularly desirous of receiving suggestions for improving its General Provisions and specifications with a view to making them conform with generally accepted commercial requirements of this character, having in mind that certain statutory requirements and accepted precedents bind Government procedure.

Upon application to the Bureau, interested parties may obtain current copies of the General Provisions and specifications for examination. Those contemplating attendance at the conference are requested to send their names to the Chief of Bureau of Yards and Docks, who will inform them as soon as practicable of the place and date of meeting.

The Engineering Association of the South will surrender its charter and disband, that being the decision of the membership announced by ballot, Dec. 1. Members of this organization feel that there is no place for a society between national and local. It is probable that the various sections of the Engineering Association of the South will continue their organizations as local societies. In the case of Nashville, this intention has already been announced and the new society will be called the Nashville Engineering Association, the committee considering the matter comprising M. A. Lightman, M. A. Rooney, and W. Harwell Allen, secretary of the old association. The Nashville Section has about 150 members.

Check Dams in the Mountain Cañons of Los Angeles County, Calif., are being constructed in accordance with the suggestions of the County Flood Control Commission, published in "Engineering News," Feb. 17, 1916. A flood control committee at Glendora, Calif., has expended $8,000 on channel protective work and the construction of check dams. Forty-two check dams were built in the Big Dalton Cañon; two with stone laid in cement mortar, and the balance of rock laid dry. In Easley Cañon 212 check dams have been constructed. Half of the money expended on this work was contributed by the County Board of Supervisors, and the other half was raised by an acreage assessment on the lands which will be benefited by the flood control work.

The World's Largest Simple Truss Span, the 720-ft. main span of the Metropolis Bridge across the Ohio, was successfully swung clear of its falsework on Dec. 11, 1916, at 3 p.m. This bridge, described in "Engineering News," July 27, 1916, connects Metropolis, Ill., with Paducah, Ky., and is part of a link connecting the C. B. & Q. R.R. in the north with the N. C. & St. L. R.R. in the south. It comprises a number of shorter spans leading up to the middle span, with its record length for a simple truss. Erection was carried on on falsework by means of derrick cars, the largest one of which had a 130-ft. boom. All top chord joints are now bolted and pinned and some web connections are riveted. Erection work was very quick, starting Aug. 26, and the top chord being closed Dec. 1. The American Bridge Co. is in charge of erection.

All the Concrete Pavements in the United States are being subjected to a maintenance survey by the field engineers of the Portland Cement Association. According to late reports, nearly 20,000,000 of the 70,000,000 sq.yd. of such pavements have been examined and reported upon, and it is expected the work will be completed during the course of the next month. Over 100 engineers stationed in various parts of the country are making this inspection. One of the objects of this survey is to secure data based on actual experience, so that methods of construction and maintenance that have produced the best results may be definitely determined with a view to raising the standards of practice in concrete-pavement construction generally. When this work is completed, the Portland Cement Association will have a complete history of all concrete pavement in the United States—roads, streets and alleys.

Bids for Four Battle Cruisers which will be far larger and more powerful than any vessels ever built for the United States Navy were opened by the Secretary of the Navy on Dec. 6. The Newport News, Wm. Cramp & Sons, Fore River and Union Iron Works companies each offered to build one of the vessels on the basis of cost plus a percentage. Newport News and Cramp offered cost plus 10%, and the Fore River and Union Iron Works, which are controlled by the Bethlehem Steel Corporation, offered to build at cost plus 15% profit, "or such percentage of profit as the Federal Trade Commission may determine to be reasonable." The two latter companies offered to complete the vessels in 48 months, and the Newport News Co. in 51 months. In submitting its proposal, the Fore River Co. stated that in view of the enormous size and power of these vessels, having six times the horsepower of any existing vessel in the Navy, and 14 knots greater speed than any of the capital ships, there is a much greater element of risk and uncertainty in the construction than in other vessels previously contracted for. The Fore River Co. further submitted alternative designs involving the use of a turbine reduction-gear drive, and a rearrangement of the boilers, placing them all below the protective deck instead of half of them above it as in the department's design. These changes in design would save about 1,000 tons in the displacement of the vessel, while the number of smokestacks are reduced from seven to three. The department design was an electrical drive. It is estimated that the substitution of the turbine reduction-gear will save $1,300,000 in the cost.

PERSONALS

E. L. Cannon has been appointed Office Engineer of the Seaboard Air Line Ry., with office at Norfolk, Va.

Meyer Davis, formerly Chief Engineer of the Asbestos Protected Metal Co., Pittsburgh, Penn., has been made Manager of the San Francisco, Calif., office of the company.

Clarence E. Kinne, M. Am. Soc. M. E., of the Bagley & Sewall Co., Watertown, N. Y., has just started on a several months' trip through China and Japan for engineering exploitation work, especially in relation to paper mills.

John L. Howard, M. Am. Soc. C. E., recently Assistant Engineer for the Directors of the Port of Boston, has been appointed Assistant to the Chief Engineer of Water-Works, Metropolitan Water and Sewerage Board, Boston, Mass.

Raymond Baffrey, President of the Hennibique Construction Co., New York City, and an officer in the French Army who has been at the front since September, 1914, is home on furlough. He will resume his military duties soon.

Henry Welles Durham, M. Am. Soc. C. E., County Engineer of Bergen County, Hackensack, N. J., and Consulting Engineer, New York City, is again enabled to resume his practice by the return of the 7th New York Infantry from the Mexican border.

Earl F. Church has resigned as Computer, United States Coast and Geodetic Survey, in order to accompany the exploring expedition of Dr. Hamilton Rice to the upper branches of the Amazon River in Brazil. He will be astronomer and topographer of the party.

C. E. Denny, formerly Signal Engineer of the New York Central Lines West of Buffalo, has been appointed Special Engineer, to work on terminal problems, in the office of J. J. Bernet, President of the New York, Chicago & St. Louis Ry. (Nickel Plate), Chicago, Ill.

Sir Alfred M. Mond, Managing Director of several large corporations including the Mond Power and Heating Gas Co. and the Power Gas Corporation, Ltd., of London, England, has been appointed First Commissioner of Works in the new Cabinet of the British Empire.

J. P. Clarke, recently with the city engineering department of Richmond, Va., and **Thos. B. Powell,** recently with the engineering department of the Chesapeake & Ohio Ry., announce the formation of the firm of Powell & Clarke, Civil and Mining Engineers, Ashland, Ky.

Sir Albert Stanley, General Manager of the London Underground Rys., has been appointed President of the Board of Trade in the new Cabinet of the British Empire. He is an American technical graduate and was Manager of the street railways in Detroit, Mich., and Newark, N. J., before going to England.

Herbert Chase, recently Laboratory Engineer and Chief Engineer of the Automobile Club of America, has been made Assistant Secretary of the Society of Automobile Engineers. He is also Treasurer of the Society and a member of its council. He is a 1908 graduate in mechanical engineering of Cornell University.

I. S. Dennis, M. Am. Soc. C. E., recently Assistant to the Second Vice-president of the Canadian Pacific Ry., with office at Calgary, Alta., in charge of the railway's department of natural resources, has been made Assistant to Lord Shaughnessy, President of the Canadian Pacific Ry., with headquarters in Montreal, Que. He will have charge of colonization and the development of natural resources.

Dr. Ira N. Hollis, President of the Worcester Polytechnic Institute, who was recently elected President of the American Society of Mechanical Engineers, was the guest of honor at a banquet tendered him by the New York Alumni of the Worcester Polytechnic Institute, Dec. 8. The guests and speakers of the evening included two of Dr. Hollis' classmates (1878) at the United States Naval Academy—M. E. Cooley, Dean of the Departments of Engineering and Architecture, University of Michigan, and Rear-Admiral Robert S. Griffin, Engineer-in-Chief of the United States Navy.

OBITUARY

Charles H. Hersey, President of the Hersey Manufacturing Co., the well known water-meter makers, of Boston, Mass., died at his home in Roxbury, Dec. 9, aged 86 years.

W. W. Scranton, President of the Scranton Gas and Water Co., said to have been largely instrumental in introducing the Bessemer process of steel making into this country, died Dec. 3, at his home in Scranton, Penn., aged 72 years. He was a descendant of the Scranton who founded the Lackawanna Iron and Coal Co., and for whom the city was named.

Frederick C. Fisher, President of the Ferro-Construction Co., Chicago, Ill., died Dec. 6. He was born at Lake Linden, Mich., 45 years ago, and was a graduate in civil engineering of the University of Michigan. In his early structural engineering experience he was employed on the construction of the famous Thebes Bridge over the Mississippi River.

Drake Whitney, a retired civil engineer of Niagara Falls, N. Y., died Dec. 4, aged 74 years. He was born at Niagara Falls. He studied engineering at the German universities of Freiburg and Heidelberg and for several years was a member of the staff of engineers which planned and built the Canadian Pacific Ry. At one time he was Village Engineer of Niagara Falls.

Richard Relf, one of the civil engineers engaged in the construction of the Northern Pacific Ry., died recently at his home in St. Paul at the age of 83 years. He had been with the Northern Pacific since 1867. In the seventies he was incapacitated from active engineering work by an injury. He was then placed in charge of the engineering records of the company, where he remained until a few years ago.

Roger Tappan, a retired civil engineer and artist died Dec. 6, at his home in Natick, Mass. He was born in Marshfield, Mass., Nov. 27, 1848. He was graduated from the Massachusetts Institute of Technology and was engaged in early railway work in both the Eastern and Western States. As a young man he taught drawing in the public schools of Salem and Haverhill, and about 1890 he gave up engineering to devote his whole time to art.

Edward M. Bigelow, M. Am. Soc. C. E., whose appointment as Director of Public Works of Pittsburgh, Penn., was noted in the "personals" columns of Nov. 30, died Dec. 6, at the Allegheny General Hospital, where he had gone for an operation. He was born in Pittsburgh, Nov. 6, 1850. He was educated in the public schools of his native city and at the Western University of Pennsylvania, now the University of Pittsburgh. Soon after graduation he was appointed Engineer of Surveys of the city, and in 1880 was chosen City Engineer. Eight years later he was made the first Director of the Department of Public Works, which position he held until 1900. He returned to this office in 1903 and continued in it until 1906. From then until 1911, when he was appointed State Highway Commissioner, he was in private practice, also serving as Consulting Engineer for the county. During the period 1880 to 1900 Mr. Bigelow had an important part in the development of the city park system. The two parks which in particular represent his work are Highland and Schenley parks. He also planned and carried out the construction of the two great boulevards of the city.

Edmund Brownell Weston, M. Am. Soc. C. E., Consulting Engineer and President of the Jewell Export Filter Co., Providence, R. I., died Dec. 9, at a private hospital in Boston, Mass. He was born at Duxbury, Mass., Mar. 25, 1850. His early engineering education and experience was obtained in the office of the chief engineer of the Providence, R. I., water-works. In 1877 he was appointed Assistant City Engineer in direct charge of the Water-Works Department. During this period he published the book "Friction of Water in Pipes." During this period also (1893-94) he made experiments to determine the efficiency of mechanical filtration for potable water-supplies, which antedated the now famous Louisville (Ky.) experiments. In 1897 he resigned from the city service and shortly after became Engineer, Manager and President of the Jewell Export Filter Co. As consulting engineer of this company he designed mechanical filter plants for many cities in this country and in Austria, India, Egypt, Germany, Japan, France, Finland, China, Korea, Siam, Italy and Ceylon. He devoted much time to original research in hydraulics and water purification, and his foreign travels and studies of water-supply and sanitary engineering were extensive. He was a member of the Institution of Civil Engineers and of the Royal Society of Great Britain. He was a bachelor and is survived by two brothers and a sister.

ENGINEERING SOCIETIES

OKLAHOMA SOCIETY OF ENGINEERS.
Dec. 27-28. Annual meeting in Tulsa. Secy., H. G. Hinckley, Oklahoma City.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 27-29. Annual meeting at Chicago. Secy., D. K. Shedd, Ames, Iowa.

COMPRESSED GAS MANUFACTURERS' ASSOCIATION.
Jan. 15. Fourth annual meeting in New York City. Secy., O. S. King, 120 Broadway, New York.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 17-18. Annual meeting at Society House, New York City. Secy., Charles Warren Hunt, New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Feb. 5-9. Eighth National Good Roads Show, in Boston, Mass. Secy., E. L. Powers, 150 Nassau St., New York City.

TENTH CHICAGO CEMENT SHOW.
Feb. 7-15. In Chicago. Under management of Cement Products Exhibition Co., 210 South La Salle St., Chicago.

AMERICAN CONCRETE INSTITUTE.
Feb. 8-10. In Chicago at La Salle. Secy., H. D. Hynds, 30 Broad St., N. Y.

NATIONAL BUILDERS' SUPPLY ASSOCIATION.
Feb. 12-13. In Chicago at Sherman. Secy., L. F. Desmond, 1211 Chamber of Commerce, Chicago.

SOUTHWESTERN CONCRETE ASSOCIATION.
Feb. 19-24. Southwestern Concrete Show in Kansas City, Mo. Address Chas. A. Stevenson, 1413 W. 10th St., Kansas City.

American Water-Works Association—Leonard Metcalf, President, announces that the 1917 convention at Richmond, Va., will be held on May 7 to 11, with headquarters at The Jefferson.

The St. Louis Association of Members of the American Society of Civil Engineers held its annual dinner Nov. 27. Col. J. A. Ockerson was reëlected President, F. G. Jonah, vice-president, and Gurdon G. Black, secretary. The election of officers was followed by several interesting addresses.

Washington Society of Engineers—A most successful annual dinner, attended by nearly 400 members and guests was held on Dec. 6. The speaking, aside from a short talk by Secretary of War Baker, was in the nature of a symposium by the professions, the lawyer, the journalist, the clergyman and the engineer being represented.

The Calgary Branch of the Canadian Society of Civil Engineers at its annual meeting on Dec. 2, elected A. Scott Dawson, chief engineer Department of Natural Resources, Canadian Pacific Ry., chairman for the ensuing year, and Sam G. Porter, assistant chief engineer, Irrigation Branch, Department of the Interior, Canada, was reëlected secretary.

The Engineers' Society of Western Pennsylvania held its annual banquet, Dec. 11, at the William Penn Hotel, Pittsburgh. The attendance was 900. The applications were 1,200 and 300 had to be turned away. The speakers were Major-General Goethals, William L. Saunders, and George Ade. The toastmaster was Edwin M. Herr, President of the Westinghouse Electric & Mfg. Co.

The American Association of State Highway Officials opened its annual meeting Dec. 5, in St. Louis at the Hotel Jefferson. The first day of the three-day meeting was devoted almost entirely to discussing the act of Congress last year appropriating $75,000,000 to aid the states in the construction of through highways. The second day was given over to addresses and papers.

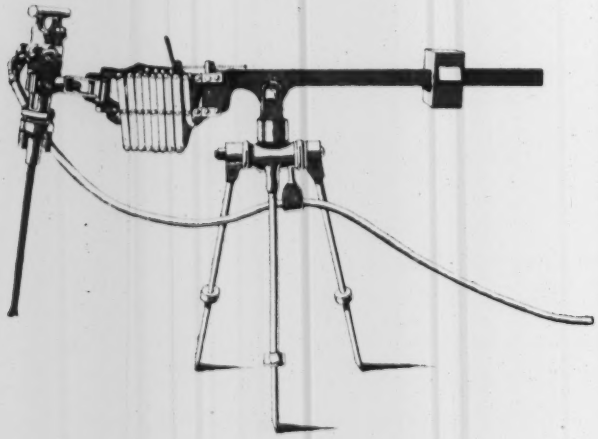
The Brooklyn Engineers' Club will hold its annual meeting Dec. 14 at 8:30. The nominations are as follows: For president, Bernt Berger; vice-president, Harry E. Funk; secretary, Joseph Strachan; treasurer, Carroll S. Dunphe; directors, Wm. J. Conway and Michael J. Shugrue; auditing committee, Carleton A. Graves, Carlos Lobo, and Howard P. Quick. The fifth presentation of the Alfred T. White Prize will be made.

New Jersey Sanitary Association—The 42nd annual meeting was held at Lakewood, Dec. 8 and 9. In the course of his annual address, Dr. Geo. E. McLaughlin, Jersey City, mentioned the reduction in the typhoid fever death rate per 100,000 in the United States from 34 in 1900 to 19 in 1914, or 44%. Geo. A. Johnson, consulting engineer, New York City, reviewed the mortality from various preventable diseases throughout the country and presented figures to show that with more liberal expenditures for health-protective work thousands of lives could be saved. Dr. John F. Anderson, late president of the American Public Health Association, sent a paper on "The Protective Use of Vaccines and Serums," in the course of which the value of anti-typhoid inoculation was illustrated by the fact that from May to November, 1916, there were only 24 cases and no deaths from typhoid fever in the regular army and mobilized National Guard, compared with some 20,000 cases and 2,192 deaths in eight months during the Spanish-American War of 1898. The water-supply problem in Northern New Jersey was sketched by Morris R. Sherrerd, consulting engineer, North Jersey Water-Supply Commission. The ultimate capacity of the Passaic River—700,000,000 gal. a day—will be reached about 1960 at the present rate of increase of demand upon that source of supply. This fact did not worry Mr. Sherrerd so much as the long delays experienced in securing the right to take water from the Wanaque River as an additional supply for Newark and other communities. This delay was attributed to the Public Utilities Commission and to the opposition of private water interests. In addition, jurisdiction is vested in the Conservation Commission. The election of officers resulted in the choice of Calvin N. Kendall, Trenton, as president, and Chester H. Wells, Montclair, chairman executive committee. Edward Guion, Atlantic City, was reëlected secretary.

Appliances and Materials

Balanced Tool Holder

An extensible balanced tool frame, intended to hold all sorts of portable tools like pneumatic riveters, chippers, busters, hand drills, tampers, grinders, etc., in their various operations, has been made by Jackson, Schmitz & Shanks Engineering Co., 15 South Desplaines St., Chicago. The device



JACKSON BALANCED TOOL HOLDER

consists of a tripod supporting, through a swivel joint and horizontal pivot, a beam made up of the tool holder and the counterbalance arm. The tool holder consists of a pair of lazytongs with a socket at the back and a grip at the front. The tool arm has a range of 16 ft. Tools weighing from 20 to 100 lb. are best accommodated.

* * *

New-Type Electric Soldering Iron

An electric soldering iron of new design has been developed by the Clemens Electrical Corporation, of Buffalo, N. Y. The wires from the supply line come to two high-resistance soldering points that are close together, but not in contact. The circuit is closed only when the iron is placed on the work to be soldered, and then the points glow, concentrating the developed heat at the point of application. A low voltage (5 to 15 volts) is needed for this type of tool, so that a step-down transformer would ordinarily be required. Another design working on the same principle has two separate tools on the ends of the soldering circuit; one makes contact with the work and the other feeds solder at the desired point.

* * *

New Insulating Material

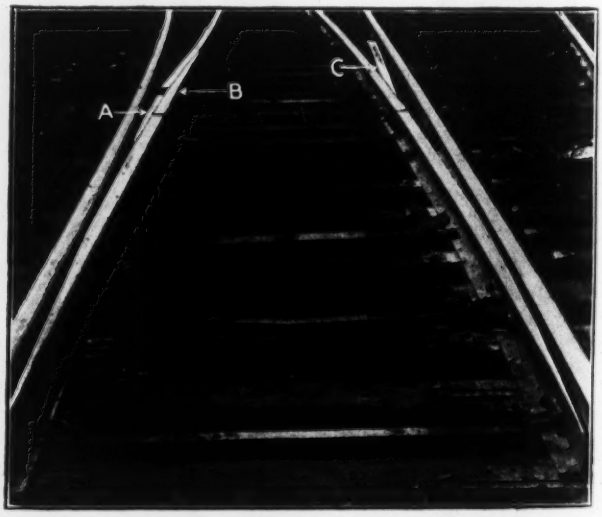
A new electric insulating material, called "Condensite-Cellulac," has been developed and patented by the Diamond State Fiber Co., of Bridgeport, Penn. As the name indicates, it is made in part of a proprietary phenol-formaldehyde synthetic resin; it has the properties of this material in that it can be supplied in the soft unformed state for use where it is advisable to cure in place. The fully cured material is supplied in sheets, rods, tubes, etc. It is claimed to have properties different from any other insulating material, combining the physical, chemical and electrical properties of "Condensite" with the mechanical condition of vulcanized fiber. It is anhydrous and nonhygroscopic and is unaffected by weather, steam, acids or oils.

* * *

New Design of Split Switch

A new split switch for railway track has the special feature of providing against derailment in the event of a train heading into it when the point rails are misplaced so that the switch is not set for either track, as shown in the accompanying view. This condition may occur owing to breakage of a rod connection or to some obstruction preventing the point rail from being closed against the stock rail. In such case the wheels would follow the diverging unbroken stock rails, with the result of derailment.

The switch has three auxiliary parts: On the turnout side are the filler bar, A, level with the underside of the head of the point rail; and the emergency trailing point, B. On the main-track side is the guard point, C. With a switch in the position shown, the flanges of the wheels on the turnout side will ride up on the filler bar and be guided into the heel of the



PLAN AND VIEW OF DUNN SAFETY SPLIT SWITCH

emergency point, forcing this point open as the wheels return to the main-track rail. Normally this point rail is held closed (as shown) by a spring, like that of a spring-rail frog. The guard point holds the wheels over sufficiently to insure that those on the turnout side will trail through the emergency point. The view shows switch installed in the approach to wheels on one side upon their flanges will tend to carry them through the emergency point without the action of the guard point. The view shows switch installed in the approach to the union passenger station at St. Paul, Minn. The switch is designed under the Dunn patents and an early type was described in "Engineering News," in 1890. It is known as the Perfection Safety Switch, and is built by the Twin City Frog and Switch Co., 1003 Germania Life Building, St. Paul, Minn.